ALBERTA MULTI-STAKEHOLDER GROUP FOR PARTICULATE MATTER AND OZONE

REPORT TO ALBERTA ENVIRONMENT

Clean Air Strategic Alliance

Alberta
ENVIRONMENT

Alberta Multi-Stakeholder Group for Particulate Matter and Ozone

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Alberta Environment Information Centre
9920 - 108 St.
Edmonton, AB T5K 2M4
ph: (780) 944-0313

OR

Clean Air Strategic Alliance
9th Floor, Sterling Place
9940 - 106 St.
Edmonton, AB T5K 2N2
ph: (780) 427-9793 fx: (780) 422-3127

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Preface and Acknowledgements

This report summarizes the work of the Multi-Stakeholder Group on Particulate Matter and Ozone (the MSG). The MSG was formed in early 1998, through the Clean Air Strategic Alliance. Its purpose was to advise Alberta Environment on the development of Canada-Wide Standards for particulate matter and ozone, and on the development of Alberta ambient air quality guidelines for these two substances. Membership and Terms of Reference of the MSG, along with a record of meetings and key milestones, are noted in Appendix A.

This report is submitted in preparation for the November 1999 meeting of the Canadian Council of Ministers of the Environment. Its structure follows the work plan developed by the MSG to fulfill its objectives. The MSG tried to reach consensus throughout its discussions. However, by design, members of the Group represented a wide variety of sectors and, therefore, consensus was not always possible. The Group did reach consensus on the recommendations and on some details related to the level, form and timing of the standards for particulate matter and ozone. In the latter case, the range of views is presented in the table in the Executive Summary and in Table 13.1 in section 13. Recommendations are presented in the Executive Summary and in the section of the report to which they pertain.

The MSG gratefully acknowledges the financial and/or in-kind support of the following companies, agencies and departments in enabling it to undertake this work:

Alberta Environment, Alberta Forest Products Association, Alberta Health and Wellness, Alberta Lung Association, Alberta Power (now ATCO), Alberta Resource Development, Bert Riggall Environmental Foundation, Canadian Energy Pipeline Association, EPCOR, Canadian Association of Petroleum Producers, Canadian Chemical Producers' Association, Canadian National, Canadian Petroleum Products Institute, Caron Transport, City of Edmonton, Clean Air Strategic Alliance, Celanese, Dow Chemical Canada, Environment Canada, Inland Cement, Fording Coal, Nova Chemicals, Prairie Acid Rain Coalition, Shell Canada Limited, Shell Canada Products Limited, Toxics Watch Society of Alberta, TransAlta Utilities, TransCanada Transmission, Trimac, the University of Alberta, and the University of Calgary.

The Group very much appreciated the support of the Secretariat of the Clean Air Strategic Alliance and the staff within Alberta Environment. These individuals provided a wide range of writing, technical, logistical and organizational support, and the Group would not have achieved its goals without their dedication and commitment. The MSG would also like to thank Kim Sanderson for her assistance with this report, as her technical writing and editing skills were highly valuable to the group.

Various reports and reviews were commissioned by Alberta Environment and by the MSG during the course of this work; full references are provided in Appendix B.

Finally, the MSG would like to acknowledge the Board of the Clean Air Strategic Alliance for its support, its contribution of resources and its encouragement in undertaking this challenge.

Contents

Acronyms Used in This Report

Acronyms are defined the first time they are used in the main body of this report and are listed here for easy reference.

AENV	Alberta Environment
AQVM	Air Quality Valuation Model
CAC	Criteria Air Contaminants
CASA	Clean Air Strategic Alliance
CCME	Canadian Council of Ministers of the Environment
CMB	Chemical Mass Balance
CWS	Canada-Wide Standard(s)
DC	Development Committee of the CCME
EPA	Environmental Protection Agency (US)
EPEA	Environmental Protection and Enhancement Act (Alberta)
GDP	Gross Domestic Product
Kt	kilotonne (one thousand tonnes)
MSG	Multi-Stakeholder Group for PM and Ozone
NAICC	National Air Issues Coordinating Committee
NEIPTG	National Emissions Inventory and Projections Task Group
NRCan	Natural Resources Canada
OECD	Organisation for Economic Cooperation and Development
PAMZ	Parkland Airshed Monitoring Zone
PM	Particulate Matter
ppb	parts per billion
SIC	Source Industrial Code
SWBR	Southern Wood Buffalo Region
TSP	Total Suspended Particulates
VOC(s)	Volatile Organic Compounds
WCAS	West Central Airshed Society
$\mu g/m^3$	micrograms per cubic metre (a microgram is one-millionth of a gram)
μm	micrometre (one-millionth of a metre)

Executive Summary

The impacts of particulate matter and ozone have become an important emerging air quality issue in Alberta and across Canada. Two size ranges of particulate matter (often referred to as "PM") are currently being investigated: PM_{10}, which refers to particulate matter that is less than 10 micrometres in diameter, and $PM_{2.5}$, which refers to particles less than 2.5 micrometres in diameter. Both PM_{10} and $PM_{2.5}$ have been associated with human health effects. Ozone is also associated with human health effects and vegetation damage.

In January 1998, the Canadian Council of Ministers of the Environment (CCME), with the exception of Quebec, signed the Canada-Wide Accord on Environmental Harmonization as well as sub-agreements dealing with environmental assessment, inspections, and development of Canada-Wide Standards (CWS). CWS are being developed for seven substances, including particulate matter and ground-level ozone. Ministers directed that the CWS for PM and ozone would be completed by November 1999. Alberta Environment is responsible for developing guidelines and ambient environmental quality objectives for this province and has a mandate to consult with the public in the process. The Clean Air Strategic Alliance agreed to assist Alberta Environment in establishing a consultation process, and a Multi-Stakeholder Group for Particulate Matter and Ozone (the MSG) was subsequently formed to fulfill the following objectives:

- provide input to the Canada-Wide Standards development process;
- recommend the level, form and application of Alberta Guidelines; and
- recommend the plan of action by which guidelines and standards will be pursued.

The MSG developed a detailed work plan to compile and evaluate existing information in a number of areas; this information was used by the Group to identify data gaps and make recommendations for filling those gaps. The areas of focus for the MSG correspond to chapters 2-12 in this report:

- Regional emissions inventories for Alberta
- Source apportionment
- Ambient air quality monitoring
- Rollback analysis
- Human exposure
- Effects of PM and ozone on health and the environment
- Benefits of lower levels of PM and ground-level ozone
- C of control technologies
- Management options
- Education
- Forecasts and future growth

The MSG did not have time to develop an independent list of recommended future actions for reducing emissions of PM and ozone, but agreed that the Group should assist Alberta Environment in developing implementation plans for the PM and Ozone Canada-Wide Standards (chapter 14).

The Group also sought consensus on the level, form and timing of the Canada-Wide Standards that should be established for PM and Ozone (chapter 13). The MSG was able to reach consensus on most of the issues it discussed, with the exception of the details related to the setting of these standards. The various stakeholder positions on the level, form and timing of standards are presented below, along with a summary of key discussion points, including areas on which the group had consensus and areas in which consensus was lacking.

MSG Discussion and Stakeholder Positions on Standards for PM and Ozone

In discussing potential standards for PM and Ozone, the MSG agreed on the following points:

- The key driver for a Canada-Wide Standard (CWS) should be human health impacts.
- CWS levels should be reviewed periodically.
- The form should be an ambient concentration.
- There should be a 24-hour standard for PM, provided the daily level is acceptable.
- A mechanism is needed to deal with naturally occurring events.
- National and regional action plans should be developed and should include emission reduction strategies and recommendations for research on:
  - the relationship and contribution of indoor and outdoor contaminants;
  - personal exposure;
  - the toxic components of PM; and
  - naturally-occurring background levels of ozone.

The Group was not able to reach consensus on:

- an attainment date for reaching the standards;
- the form the standard should take (e.g., maximum, percentile, and how to deal with natural events); and
- the level for PM and ozone.

There was agreement to have further discussion on:

- the implications of fence-line application vs. other applications of the standard;
- whether the CWS for ozone should be one-hour or eight-hour averages;
- the role of compliance in implementing the standards; and
- the need for a standard for PM_{10}.

The table on the following page summarizes the various stakeholder positions on the level, form and timing of standards for particulate matter and ozone.

Stakeholder Positions on Level, Form and Timing of Standards for PM and Ozone

	Industry	ENGO	Health 1	Health 2	Municipality
PM_{10}					
Level	deferred in favour of an action plan	three steps: 50, 40, 25 $\mu g/m^3$	deferred until more information is available		70 $\mu g/m^3$
Form	$\mu g/m^3$, 24-hr and annual target, 98th percentile, averaged over 3 years	24-hour			24-hr, 98th percentile, "interim," annual <US level
Timing	2015	2005, 2010, 2015	obtain info by 2003, set number by 2005		2005
$PM_{2.5}$					
Level	deferred in favour of an action plan	three steps: 25,20,15 $\mu g/m^3$	deferred until more information is available		30 $\mu g/m^3$
Form	$\mu g/m^3$, 24-hr, 98th percentile averaged over 3 years; annual number as well	24-hour			24-hr, 98th percentile, "interim," annual <US level
Timing	2015	2005, 2010, 2015	obtain info by 2003, set number by 2005		2005
Ozone					
Level	two steps: 70-75 ppb, 65-70 ppb	two steps: 60 ppb, 40 ppb		50 ppb	70 ppb
Form	4th highest annually, averaged over 3 years, 8-hr Caveat: it depends on Alberta achievability. From an Alberta perspective, 1-hr may make more sense	1-hr maximum		6- or 8-hr	8-hr, but 1-hr may be more appropriate
Timing	2005, 2010-2015	2005, 2010		2005	2005

Recommendations from the Multi-Stakeholder Group for PM and Ozone

2.0 Regional Emissions Inventories

The MSG recommends that:

1. the regional emissions inventories provided by Environment Canada be used only as an initial estimate. If these regional estimates are to be used in future progress or regulatory reporting, then further refinements are recommended.
2. additional work be done on methodologies related to estimating emissions inventories.
3. the uncertainties in the emissions inventories be researched further. The uncertainties for which further research is needed include:
   - emissions of PM and of ozone precursors;
   - biogenic emissions; and
   - emissions from open sources.

3.0 Source Apportionment

The MSG recommends that Alberta Environment take the lead in:

4. conducting further research on source apportionment to ensure that:
    - source profiles are accurate, reliable, comprehensive and appropriate for Alberta emitters;
    - data are gathered on additional ambient species and the way in which they fluctuate over time; and
    - models most appropriate to the Alberta situation are used and that expertise is available to correctly interpret the results.
5. collaborating with other jurisdictions to improve the methodologies for source apportionment modelling, data collection, study design and interpretation of results.
6. The MSG further recommends that the Group evaluate the forthcoming report on source apportionment and determine whether additional recommendations are needed in this area.

4.0 Ambient Air Quality Monitoring

The MSG recommends that:

7. monitoring be expanded so that data on PM_{10}, $PM_{2.5}$, and ozone, and their precursors, is collected from more areas of the province.
8. particulate monitoring focus on PM_{10} and $PM_{2.5}$ fractions of ambient air particulate matter rather than on Total Suspended Particulates alone.
9. ambient air quality monitoring be expanded to include more rural and background locations.

5.0 Rollback Analysis

The MSG recommends that Environment Canada:

10. adopt a more transparent approach that will enable stakeholders to review their rollback analysis process.
11. evaluate the use of regional photochemical models in future analysis.
12. play a leadership role and work with others (such as provincial agencies and scientific organizations) to conduct further research on regional airshed and photochemical models.
13. ensure that any future analyses include an assessment of uncertainty so that limitations can be accounted for.

6.0 Human Exposure

The MSG recommends that:

14. further investigation be undertaken to determine how emissions of particulate matter and ozone precursors correlate with ambient air quality and how ambient air quality is linked to human exposure.
15. personal exposure monitoring efforts be encouraged and supported to produce credible, scientifically defensible data for improved evidence-based decision making.

7.0 Effects of PM and Ozone on Health and the Environment

The MSG recommends that:

16. further investigation be undertaken to determine how emissions of particulate matter and ozone correlate with ambient air quality and how ambient air quality is linked with effects on human health and the environment.
17. existing data and knowledge about these issues be considered and applied as new technology is used to develop the data set (i.e., personal exposure) that will produce credible, scientifically defensible data for improved evidence-based decision making.
18. personal exposure monitoring become part of a long-term air monitoring strategy in Canada.

8.0 Benefits of Lower Levels of PM and Ground-Level Ozone

The Multi-Stakeholder Group recommends that:

19. Alberta Environment track the work presently underway at the US Environmental Protection Agency, continuing the assessment of particulate matter.
20. research be undertaken to validate the association between human health effects and ambient concentrations of PM_{10} and $PM_{2.5}$.
21. Environment Canada be approached to provide any available information on the ecological benefits of reduced levels of particulate matter or ozone pollution.
22. Alberta Environment investigate and review the "Quality-Adjusted Life Years" approach to benefit assessment for consideration in policy decisions.

23. The MSG further recommends that the Group evaluate the forthcoming report of the Royal Society's Expert Review Panel and determine if additional recommendations are needed.

9.0 Costs of Control Technologies

The MSG recommends that Alberta Environment take the lead in:

24. establishing and maintaining a database that contains key process information about Alberta source sectors that emit particulate matter and PM and ozone precursors
25. identifying control technologies that are compatible with Alberta source sector processes.
26. identifying capital and operating and maintenance costs for compatible control technologies.
27. establishing a process to periodically review and update this information.
28. engaging Alberta source sectors and other stakeholders throughout the development of these cost estimates.

29. The MSG further recommends that the Group evaluate the forthcoming report on control technologies and costs for Alberta and determine whether additional recommendations are needed in this area.

10.0 Management Options

While some actions can be taken within the province or nation-wide, every region of Alberta will have different air quality levels and emission sources. To deal with these differences, the MSG recommends that:

30. Alberta Environment take the lead and involve stakeholders in developing a provincial strategy to reduce emissions of particulate matter and precursors to PM and ozone.
31. the Alberta Government actively encourage and support the formation of airshed management zones in Alberta. In doing this, Alberta Environment should play a facilitative, supportive and monitoring role to ensure that existing zonal experience is effectively shared.
32. airshed management zones set up a process, including consultation with stakeholders, to develop, file and participate in the implementation of action plans to achieve the Canada-Wide Standards for Particulate Matter and Ozone.
33. Alberta Environment promote the use and formation of airshed management zones for other provinces within the national process.
34. Alberta Environment be established as the organization ultimately accountable for compliance with the Canada-Wide Standards across the province.
35. Alberta Environment, in consultation with stakeholders, continue to identify and evaluate administrative options (that is, non "command and control" options) for reducing emissions of particulate matter and ozone.

11.0 Education

The MSG recommends that:

36. opportunities for educating the public about PM and ozone be identified, further investigated and evaluated.
37. more effort be given to researching the possibility of combining PM and ozone education with other air quality topics that are more likely to be in the public eye (such as greenhouse gases).

12.0 Forecasts and Future Growth

The MSG recommends that:

38. the forecasts for population, transportation and energy demand be considered by Alberta Environment and by stakeholders when developing jurisdictional action plans to implement the Canada-Wide Standards for Particulate Matter and Ozone.
39. Alberta Environment and stakeholders collaborate on researching new estimates for future growth and forecasts in Alberta.

14.0 Implementation

The MSG recommends that:

40. Alberta Environment, with the assistance of the MSG, develop implementation plans for the PM and Ozone Canada-Wide Standards.

Caveats

The Multi-Stakeholder Group for Particulate Matter and Ozone faced a number of constraints in carrying out its objectives; these caveats are described briefly below.

1. **MSG Representation**

   The MSG sought representation from industry, environmental groups, provincial departments of Health and Environment, the City of Edmonton, and a public health group. This brought a wide range of views, experience and expertise to the discussion of setting standards for particulate matter (PM) and ozone. Nevertheless, some constituencies may have been under-represented or not represented at all, and any gaps in representation should be taken into account when reviewing the recommendations of this report.

2. **Expertise**

   The process of developing standards for PM and ozone is based largely on technical issues and analysis associated with many diverse fields, including respiratory health, epidemiology, toxicology, socio-economic modelling, modelling of air quality data, control technology assessment, and others. The MSG members have considerable collective expertise in air quality issues, policy development and implementation, but when the group needed specific technical advice or analysis, it sought outside expertise in the subject area as available and allowed by time and budget.

3. **Time**

   The MSG held its first meeting in April 1998 and met regularly in person or by teleconference. The Group made remarkable progress given the inherent complexity and technical nature of many of the issues associated with PM and ozone. During its 18 months of work, the group advanced its collective understanding of the issues and key data gaps associated with the development of standards for PM and ozone. Indeed, Alberta has been on the leading edge of much of the thinking around these two substances. However, MSG members were limited in the time they could contribute to this work, and substantial discussion is still needed to develop and refine potential approaches.

4. **Resources**

   Many good research projects were identified in MSG discussions on data gaps and uncertainties, but limitations on budget and time hampered members' ability to follow up and gather more information.

5. **Canada Wide Standards Process**

   The MSG's objective was to advise Alberta Environment on the development of Canada-Wide Standards for PM and Ozone. To meet this objective, the group focused on Alberta's unique nature within the national process.

6. **MSG Process**

   The MSG strived to reach consensus on PM and ozone issues, and areas of consensus are indicated in the report. When the various positions and points of view did not result in consensus, the differing positions are outlined and the group has attempted to suggest ways in which unresolved issues might be addressed.

1.0 Introduction

1.1 About this Report

This report describes the results of the work by the Multi-Stakeholder Group for PM and Ozone (the MSG) in 13 areas. Except for Chapters 13 and 14, each section of the report contains a synopsis of the subject area, a summary of the Group's discussion of the pertinent issues, the data gaps identified by the MSG, and recommendations for action.

Section 2.0: Regional Emissions Inventories. The section on Regional Emissions Inventories is a review and evaluation of existing emissions data for both natural and anthropogenic sources. Environment Canada provided data for the 11 regions in Alberta, as defined by the MSG. A number of uncertainties were identified in the inventories, and additional work is needed to improve the estimates of emissions related to PM and ozone.

Section 3.0: Source Apportionment. Alberta Environment undertook and shared with the MSG the results of a study on Source Apportionment. Source profiles were developed for local and area point sources in Edmonton and Calgary and a model was run in an effort to match these profiles with ambient PM data. Preliminary data indicate that a substantial proportion of both coarse and fine particulates could not be accounted for by the sources represented in the study. This and other shortcomings of the model suggest that much more work is needed to refine and expand this approach.

Section 4.0: Ambient Air Quality is monitored at nearly 60 stations across Alberta; of these, 13 monitor for PM_{10}, nine monitor for $PM_{2.5}$, and 22 monitor for ozone. Nevertheless, this monitoring should be expanded as there are significant monitoring gaps in the province, especially for fine particulate matter.

Section 5.0: Rollback Analysis is a technique that correlates air quality to potential growth in emissions, based on historical ambient air quality data. Environment Canada is using rollback analysis in developing Canada-Wide Standards. In the MSG's review of these analyses, it concluded that there are a number of significant limitations to simple rollback analysis and that other models may be more appropriate for use on a national level.

Section 6.0: Human Exposure. Although associations between air quality and air quality contaminants have been made, the notion of causality is still not well understood. Human Exposure studies would improve our understanding of how air quality affects human health, and could contribute credible data on which to base public policy decisions.

Section 7.0: Effects of PM and Ozone on Health and Environment. The MSG recognized that there is an association of PM and ozone ambient levels with health and environmental impacts. However, the MSG has not reached consensus that there is a causal relationship at the ambient levels typically found in Alberta. The complex nature of PM makes it hard to identify which types of particles are associated with effects. Additional work is needed to better understand the relationship between emissions, exposures and impacts.

Section 8.0: Benefits of Lower Levels of PM and Ground-Level Ozone are also very difficult to quantify. The MSG examined several models, including the Air Quality Valuation Model, and identified various limitations. The Group agreed that more research is needed to better assess and validate the benefits of reduced levels of these pollutants.

Section 9.0: Costs of Control Technologies. As part of the background for the CWS process, the CCME Development Committee for PM and Ozone prepared cost estimates for achieving various Canada-Wide Standards scenarios. The MSG reviewed these estimates and identified a number of shortcomings. The Group then commissioned a more detailed review of the estimates, which unfortunately was not completed in time for this report. The MSG strongly recommends that Alberta should be actively developing solutions and strategies that are appropriate for source sectors in this province.

Section 10.0: Management Options. Many management options are available to reduce ambient levels of PM and ozone. While the MSG's discussion of specific options was limited, the Group did agree that action is needed now to reduce emissions and that air quality issues in Alberta should be considered at both an airshed level and on a province-wide basis. The MSG strongly supports the need to establish airshed management zones throughout Alberta.

Section 11.0: Education can be an effective approach to reducing emissions, but there is presently low public awareness about the importance of PM and ozone. The MSG believes that education about PM and ozone should be investigated further and that opportunities should be sought to combine this topic with other air quality issues that already have a high public profile, such as climate change.

Section 12.0: Forecasts and Future Growth. Growth in Alberta's population, transportation and energy demands will affect PM and ozone emissions. These issues should be considered in detail when implementation plans are being developed for the Canada-Wide Standards and for Alberta guidelines.

Section 13.0: Stakeholder Positions on Standards for PM and Ozone reflected the diverse make-up of the MSG. While the Group agreed on some important points, it could not reach consensus on the level, form and timing of standards for PM and ozone. All positions are noted in this report.

Section 14.0: Implementation. The MSG did not have time to develop its own list of potential actions for implementation. For illustrative purposes, the Group has included in Appendix K a number of possible actions that were identified at the national multi-stakeholder workshop, held in May 1999, as part of the CWS process.

1.2 Alberta at a Glance

Alberta is Canada's fourth largest province in land size, population, and number of people employed. It covers 661,185 square kilometres and accounts for about one-fifteenth of the total land area of Canada. Alberta spans part of the Canadian Shield, the Rocky Mountains and foothills, and the Interior Plain of North America. Alberta lakes cover 16,800 square kilometres, while forests cover about 360,000 square kilometres of the province.

Cold winters and mild summers characterize Alberta's climate. Chinook winds carrying warm Pacific air moderate winter temperatures though much of the south, while northern Alberta experiences a more continental climate. Average annual precipitation ranges from more than 300 millimetres in semi-arid southeastern Alberta to more than 1500 millimetres in more humid mountain locations.[1]

Alberta's population of 2.9 million in 1998 represented 9.6% of the Canadian total,[2] with approximately 51% of Albertans living in the two major cities of Edmonton and Calgary. The province's economy is based mainly on agriculture, forestry, and energy resources. Alberta has also experienced growth in

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[1] Government of Alberta. 1990. *Alberta Industry and Resources*. Prepared by Alberta Economic Development and Trade, Policy Development and Coordination. Edmonton, Alberta.
[2] Statistics Canada Website. 1999. http://www.statcan.ca/english/Pgdb/People/popula.htm#pop

manufacturing and service industries such as petrochemicals, forest products, food processing, electronics, computer and business services, and tourism. The manufacturing and service industries account for approximately 70% of Alberta's Gross Domestic Product. In recent years, Alberta has consistently attracted Canada's highest per capita level of investment.[3]

The province's blend of natural resources and beauty, industry, agriculture, and recreational potential creates a challenge for environmental managers. Alberta's air quality has generally placed it among the cleaner provinces in Canada, with air quality in Edmonton and Calgary considered to be "good" over 90% of the time, according to the Index of the Quality of the Air.[4] However, one of the most important air quality issues in Alberta today concerns the two substances that are the focus of this report – particulate matter (PM) and ground-level ozone (ozone).

1.3 Background on Particulate Matter and Ozone in Alberta

Two sizes of particulate matter are currently being investigated: PM_{10} and $PM_{2.5}$. PM_{10} refers to particulate matter that is less than 10 micrometres[5] in diameter, and $PM_{2.5}$ refers to particulate matter that is less than 2.5 micrometres in diameter. Both PM_{10} and $PM_{2.5}$ have been associated with human health effects, but $PM_{2.5}$ is considered more important with respect to health because it can penetrate deep into the lungs. Ozone is also associated with human health effects and is one of the most damaging air pollutants to vegetation.[6]

Notably, emissions inventories deal only with primary sources of particulate matter. Primary particulates are emitted directly into the atmosphere while secondary particulates result from the chemical transformations of precursor emissions such as NOx, SO_2, organic compounds and ammonia. It is considerably more difficult to relate ambient concentrations of secondary particles to sources of precursor emissions than it is to identify the sources of primary particles.[7] There is both a primary and secondary component to PM emissions, while ozone is a secondary pollutant.

1.4 Harmonization and Canada-Wide Standards

On January 29, 1998, the Canadian Council of Ministers of the Environment (with the exception of Quebec) signed the Canada-Wide Accord on Environmental Harmonization designed to lead to improved cooperation and better environmental protection across Canada. The ministers also signed sub-agreements dealing with environmental assessment, inspections, and development of Canada-Wide Standards (CWS). Consensus among the ministers and meaningful stakeholder consultation are key features of the CWS Sub-Agreement.

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[3] Government of Alberta. 1990. *Alberta Industry and Resources*. Prepared by Alberta Economic Development and Trade, Policy Development and Coordination. Edmonton, Alberta.

[4] The Index of the Quality of the Air (IQUA) is a method of reporting air quality in terms that are easy for the general public to understand. This index associates concentrations of five major air pollutants to federal and provincial air quality objectives. Air quality is reported as Good, Fair, Poor or Very Poor. (R.H. Myrick and K.M. Hunt. "Air Quality Monitoring in Alberta 1996 Detailed Report." Air Issues and Monitoring Branch, Chemicals Assessment and Management Division, Alberta Environmental Protection. January 1998. (see also the CASA Website: "Alberta Ambient Air Data Management System" at http://www.casadata.org/casa/owa/)

[5] A micrometre is one-millionth of a metre, abbreviated as "µm"

[6] H.S. Sandhu. 1999. *Ground-Level Ozone in Alberta*. Report prepared for Science and Technology Branch, Alberta Environmental Protection, No. 1494-A9901. Edmonton, Alberta.

[7] H.S. Sandhu. 1998. "Ambient Particulate Matter in Alberta." Report prepared for Science and Technology Branch, Alberta Environment. No. 1494-9805, Edmonton, Alberta.

CWS are being developed for seven substances including particulate matter, ground-level ozone, benzene, mercury, dioxins and furans, and petroleum hydrocarbons in soil. The CWS have four components: a numeric level, a time frame for achievement, a list of preliminary actions, and a framework for reporting to the public. The Sub-Agreement does not provide for any change in the authority of any jurisdiction. It is a political commitment to achieve the target agreed to by environment ministers across Canada. Jurisdictions have the option of adopting regulations that are more stringent than the CWS.

A Development Committee with representatives from participating provinces and territories has been in place since February 6, 1998 to work on issues surrounding these two substances. Ministers directed that the Canada-Wide Standards for PM and ozone would be completed by November 1999.

1.5 Alberta's Consultation Requirement

The *Environmental Protection and Enhancement Act* (EPEA) provides for the development of guidelines and ambient environmental quality objectives for all or part of Alberta under Section 14. Stakeholder consultation is more than a fulfilment of legislative requirements; it is a principle of environmental management that is considered to be highly effective in Alberta. Stakeholder input is important to the development of both Alberta and national objectives and guidelines.

1.6 The Multi-Stakeholder Group for Particulate Matter and Ozone

To support the development of Canada-Wide Standards for PM and ozone, and to fulfill the mandate for public consultation under EPEA section 14, Alberta Environment proposed to the Board of the Clean Air Strategic Alliance (CASA) that CASA assist in the establishment of a multi-stakeholder consultation process to develop Alberta air quality guidelines.

Specifically, Alberta Environment recommended that CASA:

1. establish a process to provide multi-stakeholder consultation in the development of Alberta ambient air quality guidelines;
2. establish the objectives of the proposed consultation process; and
3. identify and recommend stakeholders to be involved in consultation on the development of Alberta air quality guidelines and Canada-Wide Standards for PM and ozone.

The CASA Board of Directors approved Alberta Environment's proposal at its March 1998 meeting, and a Multi-Stakeholder Group for PM and Ozone was subsequently established (see Appendix A).

The Multi-Stakeholder Group began the task of communicating with the Alberta public about PM and ozone in Alberta by drafting a communications strategy for the Consultation on Canada-Wide Standards for PM and Ozone (see Appendix C). Alberta Environment then placed an advertisement in the province's major daily newspapers on May 21, 1999. The advertisement, illustrated in Appendix C, requested public input in the development of Canada-Wide Standards for PM and ozone and indicated that questionnaires and more information were available upon request. The Department received 15 requests for questionnaires, only five of which were completed and returned. This low response indicates that the profile of the PM/ozone issue is not as high as other air quality issues. Therefore, when discussing new options for public education, it is important to consider the links between PM/ozone and other air quality issues – such as climate change – that may be more in the public eye.

2.0 Regional Emissions Inventories

2.1 Information Summary

One of the MSG's objectives was to compile and evaluate existing information, identify data gaps and make recommendations for filling gaps on emission inventories, with a particular priority to obtain regional emissions estimates for Alberta. The MSG defined 11 regions in Alberta for which emissions estimates would be necessary (Appendix D). Regions 1, 2, and 3, were defined as the existing airshed management zones; regions 4 and 5 were the areas around Edmonton and Calgary, respectively; and the rest of the province was arbitrarily divided into six additional regions. The MSG supplied these boundary descriptions to Environment Canada and requested that emissions data be provided for each of the regions. Environment Canada made this information available, giving the MSG access to 1995 Criteria Air Contaminants (CAC) Emissions Inventory data on a national, provincial and regional scale.

2.1.1 Emissions Inventories

The Criteria Air Pollutants estimated in the 1995 Emissions Inventory of Criteria Air Contaminants from Environment Canada[8] include: sulphur dioxide (SO_2), nitrogen oxides (NO_X), carbon monoxide (CO), volatile organic compounds (VOCs), total particulates (PM), particulate matter less than 10 micrometres in diameter (PM_{10}), and particulate matter less than 2.5 micrometres in diameter ($PM_{2.5}$). The inventory includes information from point sources (for example, one facility); area or open sources (for example, forest fires, road dust, and agriculture); and mobile sources (transportation). The emissions inventory data deals with both anthropogenic sources (industrial, residential, commercial, transportation) and natural sources (such as forest fires).

2.1.2 Sources of PM and Ozone in Alberta

PM and ozone are considered together because they, or their precursors, share common sources, and because they are both components of smog. In Alberta, both natural and anthropogenic sources contribute to ambient PM and ozone. Alberta may also be affected by transboundary flow of PM and ozone, or their precursor pollutants, from the US or from another province or territory.

Particulate Matter

According to the 1995 Emissions Inventory of Criteria Air Contaminants from Environment Canada,[9] Alberta's emissions of PM_{10} and $PM_{2.5}$ are higher than those of any other province or territory (Figures 2.1 and 2.2). As noted in Figure 2.3, 96% of the emissions of PM_{10} and 80% of $PM_{2.5}$ emissions are accounted for under "Open Sources," including: dust from paved and unpaved roads, agriculture (animals, tilling and wind erosion), forest fires, prescribed burning, construction operations, landfill sites and mine tailings. Most of the contribution of open sources to PM_{10} levels (61%) can be attributed to dust from unpaved roads, which are also largely responsible for most of the $PM_{2.5}$ emissions (Figure 2.4 and Appendix E).

[8] Environment Canada Pollution Data Branch Website: www.ec.gc.ca/pdb/cac/cac.html 1999. Inventory of Criteria Air Contaminants.
[9] Ibid.

Figure 2.1. Provincial Contribution to PM_{10} (based on Environment Canada's 1995 Emissions Inventory of Criteria Air Contaminants)

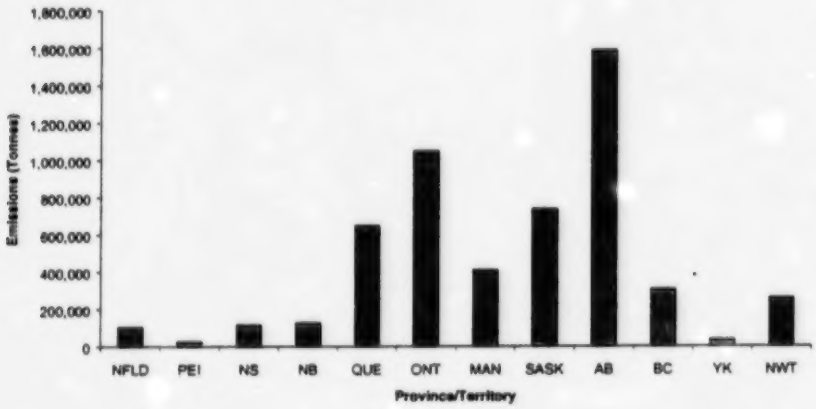


Figure 2.2. Provincial Contribution to $PM_{2.5}$ (based on Environment Canada's 1995 Emissions Inventory of Criteria Air Contaminants)

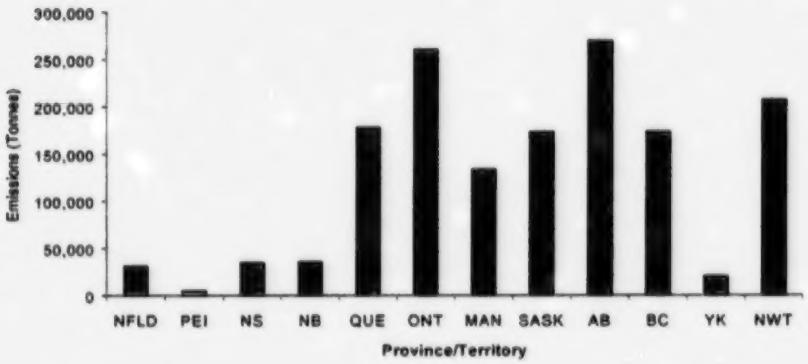


Figure 2.3. Sectoral Contribution to PM_{10} in Alberta (based on 1995 Emissions Inventory)

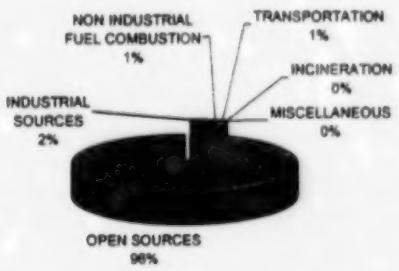
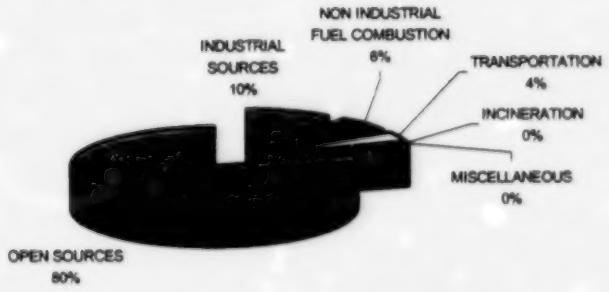


Figure 2.4. Sectoral Contribution to $PM_{2.5}$ in Alberta (based on 1995 Emissions Inventory)



Notably, emissions inventories deal only with primary sources of particulate matter. Primary particulates are emitted into the atmosphere while secondary particles result from the chemical transformations of primary emissions such as NOx, SO_2, organic compounds and ammonia. It is considerably more difficult to relate ambient concentrations of secondary particles to sources of precursor emissions than it is to identify the sources of primary particles.[10]

[10] H.S. Sandhu. 1998. "Ambient Particulate Matter in Alberta." Report prepared for Science and Technology Branch, Alberta Environment. No. 1494-9805, Edmonton, Alberta.

Ozone

Emissions inventories do not predict emissions of ozone specifically because ozone is a secondary pollutant. Ozone can result from complex reactions between nitrogen oxides and volatile organic compounds in the presence of sunlight, or it can be generated naturally in the stratosphere and transported down to ground level.

According to the 1995 Emissions Inventory of Criteria Air Contaminants,[11] Alberta's emissions of nitrogen oxides are ranked highest among all provinces (Figure 2.5). Industrial Sources, Transportation and Non-Industrial Fuel Combustion contribute 50%, 32%, and 16% of NO_X, respectively (Figure 2.6). The detailed breakdown of emissions (Appendix E) estimates that the upstream oil and gas industry, electric power generation and diesel vehicles are the highest contributors to NO_X emissions.

Figure 2.5. Provincial Contribution to NOx (based on Environment Canada's 1995 Emissions Inventory of Criteria Air Contaminants)

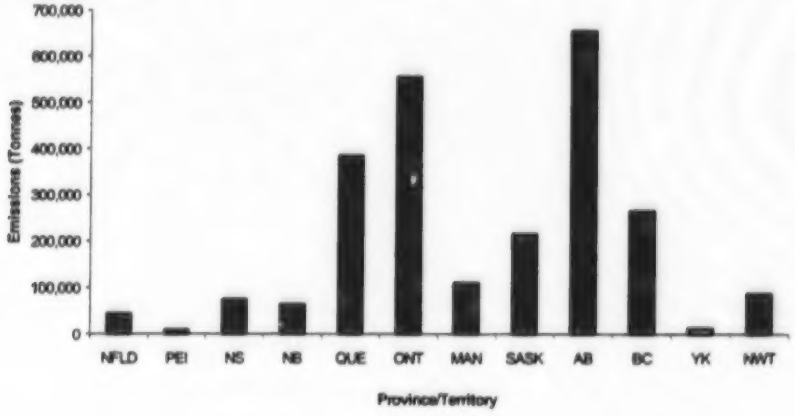
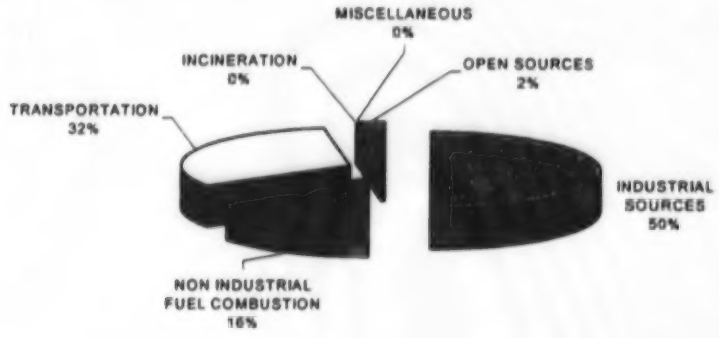


Figure 2.6. Sectoral Contribution to NOx in Alberta (Based on 1995 Emissions Inventory)



[11] Environment Canada Pollution Data Branch website: www.ec.gc.ca/pdb/cac/cac.html 1999. Inventory of Criteria Air Contaminants.

Alberta is second only to Ontario in emissions of volatile organic compounds (Figure 2.7). Figure 2.8 indicates that industrial sources contribute 65% of VOCs, with the upstream oil and gas industry contributing a substantial portion; see Appendix E for the detailed breakdown of emissions. Biogenic emissions are not included in this emissions inventory but, in Alberta, biogenic emissions (from trees, especially) are a significant contributor of VOCs.

Figure 2.7. Provincial Contribution to VOCs (based on Environment Canada's 1995 Emissions Inventory of Criteria Air Contaminants)

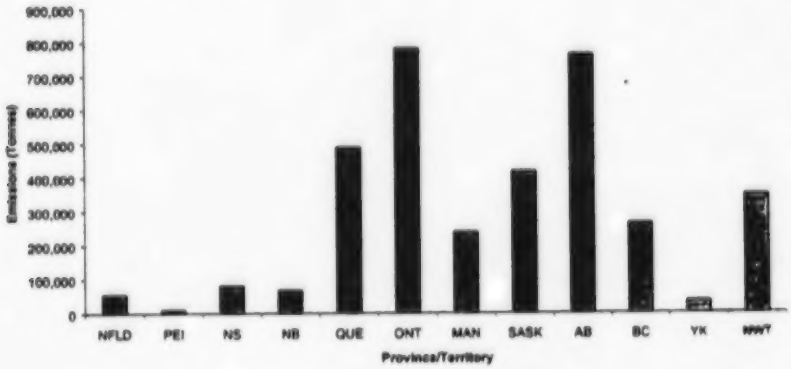
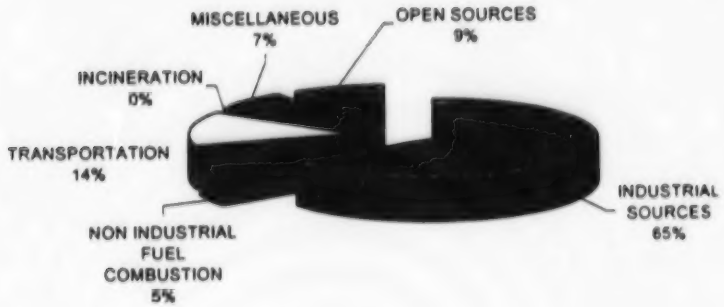


Figure 2.8. Sectoral Contribution to VOCs in Alberta (based on 1995 Emissions Inventory)



2.1.3 Regional Emissions

After identifying boundaries for the 11 proposed regions, the MSG gave descriptions of each zone to Environment Canada, and the Pollution Data Branch provided emissions estimates for each zone. The map, a summary table of emissions and the methodology are described in Appendix D. The detailed breakdown of emissions of Criteria Air Contaminants for each zone is provided in Appendix F.

Figures 2.9-2.12 illustrate the amount of particulate matter, NOx and VOCs contributed by each region. The actual numbers are provided in Table 2.1. The predicted regional emissions indicate that the West Central Zone has the highest emissions of PM_{10} and $PM_{2.5}$. The Edmonton region has the largest emissions of NO_X, while the Calgary region has the highest VOC emissions.

Figure 2.9. Regional Contribution to PM_{10} (based on Environment Canada's 1995 Emissions Inventory)

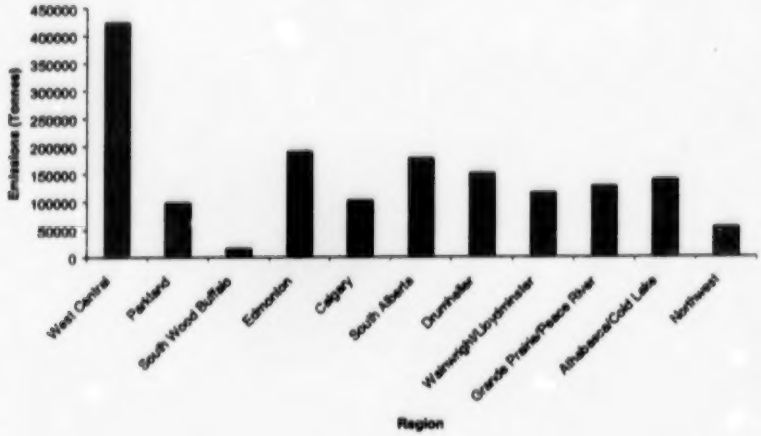


Figure 2.10. Regional Contribution to $PM_{2.5}$ (based on Environment Canada's 1995 Emissions Inventory)

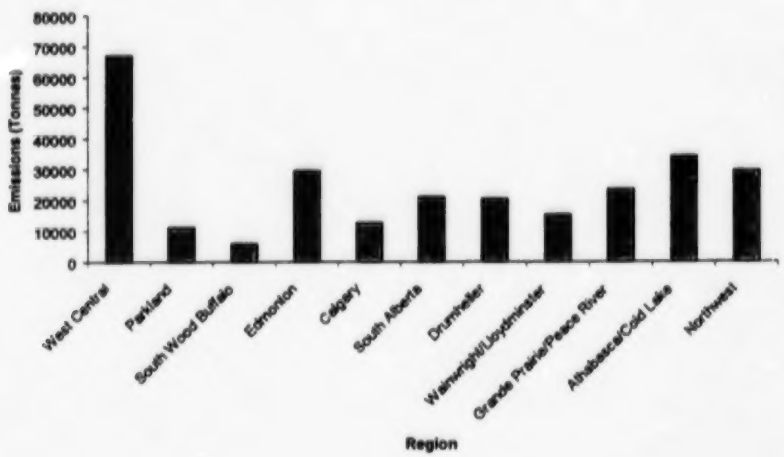


Figure 2.11. Regional Contribution to NOx (based on Environment Canada's 1995 Emissions Inventory

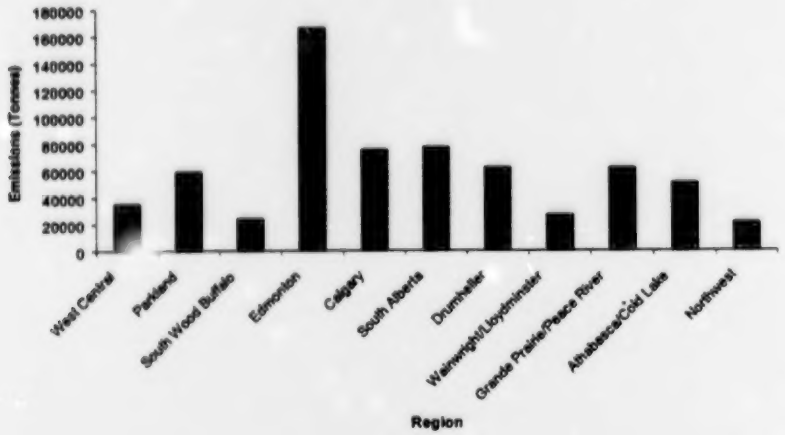


Figure 2.12. Regional Contribution to VOCs ((based on Environment Canada's 1995 Emissions Inventory

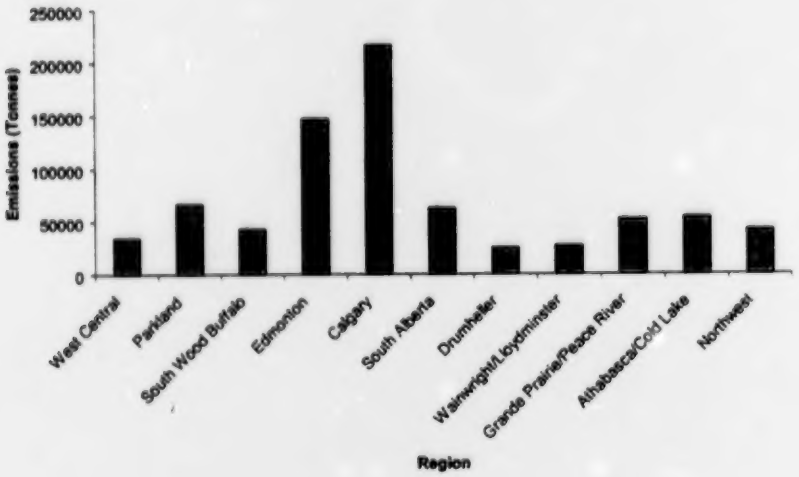


Table 2.1. 1995 Criteria Pollutant Emissions (tonnes) by Airshed*

REGION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOCs	CO
West Central	1,509,504	423,118	66,936	23,983	34,616	33,514	120,597
Parkland	288,518	97,011	11,049	57,792	58,643	65,724	118,731
South Wood Buffalo	39423	14,087	5,782	167,527	23,382	41,979	47,453
Edmonton	614,911	188,918	29,361	99,636	165,253	146,619	367,347
Calgary	373,792	100,764	12,644	57,952	74,736	216,081	231,235
South Alberta	526,715	176,951	20,986	32,510	76,540	62,008	200,851
Drumheller	467,289	149,627	20,335	77,758	61,545	24,582	53,590
Wainwright/Lloydminster	365,929	114,167	15,118	4,497	26,244	26,053	71,534
Grande Prairie/Peace River	379,161	126,107	23,312	69,523	60,995	51,492	195,771
Athabasca/Cold Lake	389,285	137,633	34,092	14,476	50,325	53,445	250,809
Northwest	100,705	52,034	29,339	2,451	20,741	41,204	342,783
Alberta Total	**5,055,231**	**1,580,418**	**268,954**	**608,105**	**653,020**	**762,701**	**2,000,701**

* Airshed boundaries as defined by the Multi-Stakeholder Group on PM and Ozone
Data source: Environment Canada, March 1999

2.2 MSG Discussion

After reviewing the emissions information provided by Environment Canada, the MSG had three questions. These are noted below along with summaries of the initial responses provided by Environment Canada's Pollution Data Branch.

Question 1. Why are West Central PM emissions significantly higher than the other regions?

In the West Central Region, PM emissions are high due to total dust from unpaved roads. In Environment Canada's calculation for dust from paved and unpaved roads, two variables are used: total precipitation and length of roads by road type. The high value could be affected by the large number of unpaved roads and possibly by the low total precipitation in 1995 for the region.

Question 2. Why are Edmonton's PM emissions higher than Calgary's?

Edmonton's emissions are higher than Calgary's because of the size of the regions. The variables considered are length of roads and road type. Because the Edmonton Region is approximately twice as big as the Calgary Region, it has higher transportation emissions.

Question 3. Why are Edmonton's transportation emissions higher than for Calgary (all pollutants)?

Because the Edmonton Region is geographically much bigger than the Calgary Region, more roads are included (especially unpaved roads). Total precipitation is also a possible cause for higher PM emissions from unpaved roads.

The MSG is currently exploring a more detailed explanation to these three questions.

2.3 Data Gaps

The Emissions Inventory of Criteria Air Contaminants only estimates the contribution of primary pollutants. Secondary pollutants are not included in the emissions inventory and this is important when considering predicted emissions of $PM_{2.5}$, as secondary formation of $PM_{2.5}$ may make up a considerable portion of total $PM_{2.5}$ in the atmosphere. This needs further investigation.

Road dust emissions contribute a large portion of PM_{10} and $PM_{2.5}$ emissions in Alberta. These estimates are associated with a high degree of uncertainty. Further effort is needed to refine these estimates.

There is no explicit emissions inventory for ozone, as it is a secondary pollutant. NO_X and VOC emissions may only give an indication of ozone levels. Ozone concentrations in the atmosphere are generally predicted by complex photochemical modeling, using NO_X and VOC emission estimates as inputs.

Biogenic emissions of VOCs are not included in the 1995 Emissions Inventory. Trees and other natural sources may be a significant source of VOCs in Alberta and this needs to be examined further.

Open sources, such as transportation, are associated with a high level of uncertainty and require further investigation. The assumptions used in measuring data from non-industrial sources are not totally clear.

2.4 Recommendations

The MSG recommends that:

1. the regional emissions inventories provided by Environment Canada be used only as an initial estimate. If these regional estimates are to be used in future progress or regulatory reporting, then further refinements are recommended.
2. additional work be done on methodologies related to estimating emissions inventories.
3. the uncertainties in the emissions inventories be researched further. The uncertainties for which further research is needed include:
    - emissions of PM and of ozone precursors;
    - biogenic emissions; and
    - emissions from open sources.

3.0 Source Apportionment

3.1 Information Summary

One of the objectives in the MSG's workplan was to "compile and evaluate existing information, identify data gaps, and make recommendations for filling gaps on the results of the source apportionment study." This study was undertaken by the Alberta Research Council for Alberta Environment to estimate the contributions of various Alberta sources to ambient PM levels to which a receptor is exposed. Alberta Environment shared the results of this study with the MSG to help the Group develop a better understanding of:

- the background levels of PM;
- the contribution of sources in the area being examined, especially sources of large amounts of PM such as forest fires; and
- the distribution of emissions from point sources.

The study involved a mathematical computation using Chemical Mass Balance (CMB) software, which required knowledge of the concentration of chemical species[12] in ambient air as well as in each source in the vicinity of the receptors. Edmonton and Calgary were selected as sites for the study. Modelling was then done on a yearly and a seasonal (winter, spring, summer, and fall) basis for both fine PM and coarse PM,[13] using ambient data provided by Alberta Environment for the 1995-1997 period.

Prior to running the model, profiles of potential sources were developed so that emissions could be accurately estimated. These profiles contained complete information on 80 chemical species for local area and point sources specific to Edmonton and Calgary. Because local profiles have not yet been developed for all potential emissions sources, in some cases it was necessary to supplement this information with profiles from other databases.[14] The source apportionment study used the US Environmental Protection Agency's (EPA) Chemical Mass Balance Model (CMB Version 8.0).[15]

3.2 MSG Discussion

The final results of the source apportionment study were not yet available when this report was prepared. Preliminary results for both Edmonton and Calgary indicate that, of the sources represented in the study, the transportation sector is the single largest source of PM emissions on an annual basis. However, represented sources could account for only 20-25% of the total mass of ambient coarse particulates in both cities. In Edmonton, sources represented in the study could account for almost 2/3 of the total mass of fine particulates, but in Calgary, sources for nearly half of the fine particulates were unexplained.

The MSG recognized that the CMB model has a set of default assumptions and requirements, which calls for careful interpretation and use of the results. One important concern for the group was the fact that some sources may have similar profiles, making it difficult to distinguish them in a CMB study. Such

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[12] In chemistry, the term "species" refers to a chemical entity, such as a particular atom, ion, or molecule.

[13] "Fine" PM refers to particulate matter that is 2.5 μm in diameter or less, and "coarse" PM refers to particulate matter that is between 2.5 and 10 μm in diameter.

[14] The US Environmental Protection Agency's Particulate Matter Speciation Data System and the Desert Research Institute's DESERT Database provided supplementary information.

[15] The EPA's protocol was followed in applying and validating the CMB model. US EPA. 1987. *Protocol for Applying and Validating the CMB Model.* Prepared by Air Management Technology Branch, Monitoring and Data Analysis Division and Desert Research Institute. Reno, Nevada. May 1987. The Alberta Research Council describes the history, justification, and assumptions of the CMB model in its 1998 report: *Overview on Particulate Matter.*

sources could be combined to avoid reaching misleading conclusions about specific sources. As well, the source profile, which was based on only one or two days of sampling, could change over time, leading the MSG to believe that, at this stage, modelling results should be used to estimate sector contributions rather than to identify specific point sources.

Different models (mainly area models) have been used in other jurisdictions, including British Columbia, Ontario and the US. Environment Canada is presently collaborating with Alberta Environment to apply the Urban Airshed Model-V for Particulate Matter to PM source apportionment in Alberta, and results are expected by the end of 2000.

3.3 Data Gaps

The MSG identified several gaps associated with the source apportionment study.

a) Limited ambient speciation data
   - Fewer parameters were found in source profiles developed by the Alberta Research Council than in ambient profiles.
   - Only ambient speciation data from Edmonton and Calgary were available for the study, and data for other locations are needed to run additional Alberta simulations.

b) Limited source profiles
   - The fluctuations in species concentrations over time for each profile have not been evaluated.
   - An expanded source profile database is needed to enable a more complete attribution of emissions to a particular source or sector.
   - New source types and profiles are needed for the CMB model (e.g., improved point source profiles).

c) Unrefined modelling methods
   - More time is needed to refine the models and modelling methodology to address episodes of high PM levels.

d) Lack of other models against which to compare the CMB model
   - CMB is presently the only tool available to the MSG, making it impossible to compare it with other models.

3.4 Recommendations

The MSG recommends that Alberta Environment take the lead in:

4. conducting further research on source apportionment to ensure that:
   - source profiles are accurate, reliable, comprehensive and appropriate for Alberta emitters;
   - data are gathered on additional ambient species and the way in which they fluctuate over time; and
   - models most appropriate to the Alberta situation are used and that expertise is available to correctly interpret the results.
5. collaborating with other jurisdictions to improve the methodologies for source apportionment modelling, data collection, study design and interpretation of results.

6. The MSG further recommends that the Group evaluate the forthcoming report on source apportionment and determine whether additional recommendations are needed in this area.

4.0 Ambient Air Quality Monitoring

4.1 Information Summary

This summary is based primarily on information from three studies: *Ambient Particulate Matter in Alberta,*[16] *Ground Level Ozone in Alberta (Draft),*[17] and *Alberta Ambient Particulate Matter and Ozone Monitoring Data Review,*[18] referred to here as the Levelton report. The MSG defined 11 regional airshed boundaries for Levelton to use in their analysis (see Appendix D).

Four groups collect information on ambient air quality in Alberta: Environment Canada, Alberta Environment, Industry (both required and voluntary), and Industry Associations and Regional Air Quality Associations. The Levelton study analyzed data from 13 Alberta Environment ambient air monitoring stations and from 46 other stations operated by industry or regional airshed associations. Thirteen of these stations monitor for PM_{10} concentrations and nine for $PM_{2.5}$. Twenty-two stations monitored ozone concentrations. Total Suspended Particulates (TSP) are not considered in this compendium because Canada-Wide Standards for particulate matter (PM) are based on PM_{10} and $PM_{2.5}$ levels.

An analysis of PM_{10} data (Table 4.1) indicated that levels varied between 0 $\mu g/m^3$ and 187 $\mu g/m^3$ (24-hour averages). While the spring and fall periods tend to have higher PM_{10} concentrations, no consistent seasonal trend existed across the different zones.

Table 4.1. Summary of Statistical Analysis of the PM_{10} 24-Hour Average Ambient Concentrations ($\mu g/m^3$)

Zone	Name[19]	Max	Min	Mean	Median	Std Deviation
1	WCAS	104	0	18	14	13
4	Edmonton	175	1	23	20	15
5	Calgary	187	3	27	23	15
9	Grande Prairie	170	0	15	10	17
10	Athabasca	46	1	18	15	10
11	Northwest	82	1	16	13	14
	Province	187	0	21	18	16

[16] H.S. Sandhu. 1998. *Ambient particulate matter in Alberta.* Prepared for Science and Technology Branch, Alberta Environmental Protection.

[17] H.S. Sandhu. 1999. *Ground-level ozone in Alberta.* Prepared for Science and Technology Branch, Alberta Environmental Protection.

[18] Levelton Engineering Ltd. 1999. *Alberta Ambient Particulate Matter and Ozone Monitoring Data Review.* Prepared for the Alberta Multi-Stakeholder Group for Particulate Matter and Ozone.

[19] Alberta has three formal airshed monitoring zones: the West Central Airshed Society (WCAS), the Southern Wood Buffalo Region (SWBR), and the Parkland Airshed Monitoring Zone (PAMZ).

An analysis of the data for $PM_{2.5}$ (Table 4.2) indicated that levels varied between 2 $\mu g/m^3$ and 143 $\mu g/m^3$ (24-hour averages). The January/February and August/September periods tend to have higher $PM_{2.5}$ concentrations, but no consistent seasonal trend existed across the different zones.

Table 4.2. Summary of Statistical Analysis of the $PM_{2.5}$ 24-Hour Average Ambient Concentrations ($\mu g/m^3$)

Zone	Name	Max	Min	Mean	Median	Std Deviation
3	SWBR	82	2	9	7	7
4	Edmonton	109	2	12	9	9
5	Calgary	143	2	12	9	9
Province		143	2	10	8	8

For ozone, considerably more data is available for analysis than is the case for PM_{10} and $PM_{2.5}$. Table 4.3 summarizes the ozone data and, while there are several "outliers," the highest readings across the zones were fairly consistent.

Table 4.3. Summary of Statistical Analysis of the Ozone 1-Hour Average Ambient Concentrations (ppb)

Zone	Name	Max	Min	Mean	Median	Std Deviation
1	WCAS	185	0	34	35	14
2	PAMZ	362	1	31	31	14
3	SWBR	77	0	21	20	14
4	Edmonton	92	1	20	18	14
5	Calgary	84	1	18	16	14
8	Lloydminster	106	1	31	31	13
9	Grande Prairie	76	1	28	29	12

The Levelton report[20] provided maximum, minimum, mean, median and standard deviation statistics for Alberta ambient data. Some stakeholders have proposed Canada-Wide Standards that include different statistics, such as the 98th percentile (for PM) and 4th highest (for ozone) measurement annually. In order to compare Alberta's ambient data to these proposed statistics, the following tables were constructed by Alberta Environment to supplement the ambient data analysis in the Levelton report. The Alberta Environment analysis used data from the CASA data warehouse (on the Internet) and data obtained for the Levelton report. This data was statistically analyzed into a form comparable to the form proposed for the PM and Ozone Canada-Wide Standards.

The tables for PM (Tables 4.4 and 4.5) are in units of the three-year average of the annual 98th percentile 24-hr concentration. Some of the data was not available for a three-year period, so the most recent data is provided. This data indicates that the highest PM levels appear at the Edmonton Northwest and Calgary Central stations.

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[20] Levelton Engineering Ltd. 1999. *Alberta Ambient Particulate Matter and Ozone Monitoring Data Review.* Prepared for the Alberta Multi-Stakeholder Group for Particulate Matter and Ozone.

Table 4.4. Three-Year Average of the 98th Percentile 24-Hour PM_{10} Concentrations in Alberta

Zone	Station	Years	3 year Average of the 98th Percentile 24-hour PM_{10} Concentration ($\mu g/m^3$)
1	Weyerhaeuser Edson - Continuous	1997-1998	52.8**
4	Edmonton Central - Intermittent	1995-1997	39.4
4	Edmonton Northwest - Intermittent	1996-1998	78.7
4	Edmonton Northwest - Continuous	1996-1998	62.9
5	Calgary Central - Intermittent	1996-1998	46.8
		1995-1997	51.6
5	Calgary Central - Continuous	1996-1998	66.3
9	CANFOR Grande Prairie - Intermittent	1998	142.6*
9	DMI Peace River - Intermittent	1996-1998	38.5
		1995-1997	34.6
9	Weyerhaeuser Grande Prairie - Continuous	1998	48.6*
10	Millar Western Boyle - Intermittent	1998	37.0*
11	High Level Forest Products - Intermittent	1996-1998	49.0
		1995-1997	51.3

* only one year of data available

** only two years of data available

Table 4.5. Three-Year Average of the 98th Percentile 24-Hour $PM_{2.5}$ Concentrations in Alberta

Zone	Station	Years	3 yearAverage of the 98th Percentile 24-hour $PM_{2.5}$ Concentration ($\mu g/m^3$)
3	Fort McMurray - Continuous	1998	25.5*
4	Edmonton Central - Intermittent	1996-1998	17.5
		1995-1997	17.8
4	Dow Chemical - Continuous	1996-1998	6.4
4	Sherwood Park - Intermittent	1998	64.0*
5	Calgary Central - Intermittent	1995-1997	27.1
5	Calgary Central - Continuous	1998	33.4*

* only one year of data available

The table for Ozone (Table 4.6) is in units of the three-year average of the annual 4th highest 8-hr concentration. From this summary data, the rural stations at Caroline and Hightower Ridge appear to have the highest ozone levels.

Table 4.6. Three-Year Average of the 4th Highest 8-Hour Ozone Concentrations in Alberta

Zone	Station	Years	3 year Average of the 4th Highest 8-hour Ozone Concentration (ppb)
1	Hightower Ridge	1996-1998	66
1	Violet Grove	1996-1998	63
2	Shell Caroline	1996-1998	68
		1995-1997	63
3	Fort McMurray (AENV)	1995-1997	54
4	Edmonton Central	1996-1998	51
4	Edmonton East	1996-1998	57
4	Edmonton Northwest	1996-1998	62
4	Fort Saskatchewan	1996-1998	62
5	Calgary Central	1996-1998	46
5	Calgary East	1996-1998	52
5	Calgary Northwest	1996-1998	60
7	Esther	1996-1998	58
8	Royal Park	1994-1996	60

The Levelton study found that:

- ozone concentrations are generally lower at urban locations than in rural areas;
- areas with potential influences from local industry do not necessarily record higher concentrations than the "background" monitoring sites; and
- high ozone concentrations are typically associated with high ambient temperatures, with the highest concentrations found in the March/April/May time period.

4.2 MSG Discussion

The MSG noted the following points in its discussion of ambient air quality monitoring:

- Monitoring for $PM_{2.5}$, PM_{10}, and ozone is not conducted extensively throughout the province and significant gaps exist within the province (specifically with fine particulate matter).
- Strong seasonal trends exist for ambient ozone.
- Decisions about guidelines and standards for ambient air particulate matter are presently based on a very limited amount of data and science.

4.3 Data Gaps

The following data gaps were identified by the MSG:

- Four of the 11 zones do not have any ground-level ozone ambient air quality monitoring.
- Two of the 11 zones do not have any particulate matter ambient air quality monitoring.
- A substantial portion of the existing Alberta particulate matter monitoring is focussed on Total Suspended Particulates (TSP) rather than $PM_{2.5}$ or PM_{10}.
- Most of the monitoring for PM and ozone focuses on urban areas and industrial development.

4.4 Recommendations

The MSG recommends that:

7. monitoring be expanded so that data on PM_{10}, $PM_{2.5}$, and ozone, and their precursors, is collected from more areas of the province.
8. particulate monitoring focus on PM_{10} and $PM_{2.5}$ fractions of ambient air particulate matter rather than on Total Suspended Particulates alone.
9. ambient air quality monitoring be expanded to include more rural and background locations.

5.0 Rollback Analysis[21]

5.1 Information Summary

Rollback analysis is a relatively old and simple technique that stems from air quality management practices dating back to the early 1960s.[22] Rollback analysis is based on an empirical, linear model that correlates air quality to potential growth in emissions, based on historical ambient air quality data. It has generally been used in urban areas when emissions are expected to rise due, for example, to new development or increased transportation. The historical emissions patterns are known and, from that, the rollback analyst can derive a relationship that projects future emissions. With knowledge of the ambient air quality guidelines, the analyst can then determine how much emissions will need to be reduced in order to comply with the guidelines. Rollback analysis has been conducted in urban environments for carbon monoxide and other non-reactive primary pollutants. There are two types of rollback modelling:[23]

1. **Simple Rollback (or Proportional) Modelling** – These models assume that the concentration of any long-lived pollutant at any point equals the background concentration of that pollutant plus some linear function of the total emission rate of that pollutant in the area.
2. **More Advanced Rollback Modelling** – These are dispersion models that can more accurately define the relationship for the source-receptor interaction. An example of this would be chemical mass balance modelling.

Environment Canada is using simple rollback analysis in developing the Canada-Wide Standards.[24] The MSG examined the analyses conducted by Environment Canada to determine: a) what methodology was used, b) if it is the most appropriate methodology, and c) how the methodology was used. The MSG recognized there are limitations to the use of rollback analysis and these are summarized in Appendix G.

5.2 MSG Discussion

It appears that the Environment Canada analysis for ozone was a modified simple rollback analysis. In the case of PM, it was stated in Annex A of Appendix E of the Science Assessment Document[25] that a proportional linear rollback was used to simulate attainment of the range of optional Canada-Wide Standard levels. Rollback analysis talks about "rolling back" emissions to meet ambient standards, but Environment Canada seems to "roll back" ambient concentrations. It was difficult to follow how the rollback translated into costs. It appears that necessary emission reductions were determined using the simple rollback modelling approach discussed by De Nevers et al,[26] then costs were applied to these reductions. If this was the case, then the limitations, as noted in Appendix G, would apply to this analysis. There are several references to "order of magnitude" estimates, but more definitive discussions of the limitations and possible error would be helpful.

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[21] This section is a summary of input received from Dave Slubik with Alberta Environment.

[22] R.I. Larsen. 1967. "Determining Reduced-Emission Goals Needed to Achieve Air Quality Goals - A Hypothetical Case," *Journal of the Air Pollution Control Association*, vol. 17, No. 12.

[23] N. De Nevers and J. Roger Morris. 1975. "Rollback Modelling: Basic and Modified," *Journal of the Air Pollution Control Association*, vol. 25, No. 9.

[24] Canada-Wide Standards Development Committee. May 1999. *Discussion Paper on PM and Ozone: Canada-Wide Standard Scenarios for Consultation*: Appendix E ("Estimates for Ambient PM and Ozone Reduction Benefits"), Annex A ("Methodology Used to Estimate the Air Quality Changes for Each Scenario").

[25] Ibid.

[26] N. De Nevers and J. Roger Morris. 1975. "Rollback Modelling: Basic and Modified," *Journal of the Air Pollution Control Association*, vol. 25, No. 9.

From the documentation provided by Environment Canada, it was not clear how the rollback model worked nor were the published limitations of the model addressed. The interpretations in this section of the MSG report were formulated with additional help from the literature on rollback analysis.

5.3 Data Gaps

The main gap identified was the fact that other, more sophisticated, available models had not been considered. These models could be used to simulate and predict air quality indicators and would address pollutant diffusion and transport, chemical transformation, and deposition processes. A comparison between simple rollback analysis, which is meant for application in urban settings rather than on a national or rural basis, and other models would have been useful.

5.4 Recommendations

The MSG recommends that Environment Canada:

10. adopt a more transparent approach that will enable stakeholders to review their rollback analysis process.
11. evaluate the use of regional photochemical models in future analysis.
12. play a leadership role and work with others (such as provincial agencies and scientific organizations) to conduct further research on regional airshed and photochemical models.
13. ensure that any future analyses include an assessment of uncertainty so that limitations can be accounted for.

6.0 Human Exposure

6.1 Information Summary

Epidemiological studies – also known as "ecological studies" – have been used to establish possible links between air quality and health outcomes. While associations between air quality and air quality contaminants have been established, causality is not well understood, nor is the contributory apportionment of outdoor and indoor air.

The strength of epidemiological studies is that they provide evidence of the association between air quality and health. However, their weakness relates to judgements regarding causality: they lack the direct link between personal exposure to a contaminant and the resulting health outcome. They also do not tell us anything about individual exposure or individual risk.

6.2 MSG Discussion

Emissions measurement, dispersion modelling and correlation of those model results with actual air station monitoring data need to be better understood. Existing data and knowledge should not be set aside or discounted. However we now have the technology to develop a data set (i.e., personal exposure) that will produce credible, scientifically defensible data for improved evidence-based decision making.

Other activities should be encouraged, consistent with the terms of reference and experience of the Alberta Oilsands Community Exposure and Health Effects Assessment Program; for example:

- Describe the population and personal distribution of exposure to airborne chemicals and particulates:
  - estimate the population distribution of selected airborne chemicals and particulates;
  - estimate the seasonal variation of exposure; and
  - characterize the personal variation of exposure as a function of individual activity patterns.
- Quantify the relative contribution of various exposure sources and pathways to airborne chemicals:
  - quantify the relative contribution of outdoor and indoor air to the total exposure.
- Describe associations between exposure to airborne chemicals and human health effects:
  - analyse occurrence relationships between selected exposures, biomarkers and health outcomes.

Personal exposure monitoring data will help us better understand the relationship between air quality and human health outcomes.

6.3 Data Gaps

The MSG noted the following data gaps:

- identification of the responsible component(s) of air quality that is/are causally associated with adverse health effects;
- a description of the population and personal distribution of exposure to airborne chemicals and particulates;
- understanding the relative contribution of various exposure sources and pathways to airborne chemicals (that is, the relative contribution of outdoor and indoor air to the total exposure); and
- quantification of dose-response relationships for specific pollutants associated with health impacts.

6.4 Recommendations

The MSG recommends that:

14. further investigation be undertaken to determine how emissions of particulate matter and ozone precursors correlate with ambient air quality and how ambient air quality is linked to human exposure.
15. personal exposure monitoring efforts be encouraged and supported to produce credible, scientifically defensible data for improved evidence-based decision making.

7.0 Effects of PM and Ozone on Health and Environment

7.1 Information Summary

Epidemiological studies consistently show that human mortality and morbidity are associated with ambient air quality. Studies in the early 1990s focused on PM_{10} and, increasingly, on $PM_{2.5}$, but recent investigations have looked more broadly at a wide range of air pollution indicators, including carbon monoxide, ozone, SOx and NOx. Generally, no threshold has been found in these studies below which effects do not occur, and it is generally accepted that increases in PM and ozone correlate with subsequent increased mortality. However, quantifying these effects for the purposes of defining a dose-response relationship that could be used in setting standards is extremely difficult for a number of reasons:

- Air is a complex mixture of substances, and most pollutants exhibit strong covariance in their ambient levels.
- Human exposure to air pollutants can be significantly influenced by indoor air quality, so the results of available epidemiological studies must be interpreted carefully and with caution.
- PM is not a single substance, but a mixture with highly complex and changing characteristics. Some particles are inorganic, some are carbon-based, and some are acidic due to sulphate or nitrate components. Furthermore, smaller particles tend to be produced and modified in the air by a complicated series of chemical reactions involving sulphates, nitrates, ammonia, volatile hydrocarbons and water.
- The situation for ozone may not be as complicated as it is for PM, but the relative contribution of various exposure sources and pathways has not been quantified in terms of total exposure.

The need to protect the health of Albertans is paramount, but intervention strategies must be carefully designed and implemented so as to focus our energies appropriately and not waste resources. A framework for a comprehensive human health and air quality monitoring system in Alberta has been prepared by a CASA project team, and implementation of this system is proceeding.

7.2 MSG Discussion

The MSG recognizes the complexities of developing and implementing guidelines for PM and ozone. Positions of individual members vary widely, with some pushing for very low standards over a short timeframe, and others promoting higher standards with opportunities to revisit them on a regular basis. All agreed on the need to identify and take actions now to improve air quality in those areas of the province where it is appropriate, and that personal exposure monitoring data is needed to help us better understand the relationship between air quality and human health outcomes.

The group discussed concepts such as the precautionary principle, continuous improvement, and science-based decision making to determine how these concepts could aid in the discussions. All of these concepts are important, but they have not materially helped in developing recommendations.

7.3 Data Gaps

Data gaps include the following:

- identification of the responsible component(s) of air quality that is/are causally associated with adverse health effects. For PM, this means identifying types of particles that are and are not associated with effects (e.g., crustal PM, road dust, secondary particles, acidic or basic particles, metal-containing material, urban aerosols);

- a description of the population and personal distribution of exposure to airborne chemicals and particulates;
- understanding of the relative contribution of various exposure sources and pathways to airborne chemicals (i.e., the relative contribution of outdoor and indoor air to total exposure);
- quantification of dose-response relationships for specific pollutants associated with health impacts;[27]
- understanding of the relationship between health effects arising from air quality issues in comparison to other determinants of health; and
- understanding which populations are at greatest risk.

7.4 Recommendations

The MSG recommends that:

16. further investigation be undertaken to determine how emissions of particulate matter and ozone correlate with ambient air quality and how ambient air quality is linked with effects on human health and the environment.
17. existing data and knowledge about these issues be considered and applied as new technology is used to develop the data set (i.e., personal exposure) that will produce credible, scientifically defensible data for improved evidence-based decision making.
18. personal exposure monitoring become part of a long-term air monitoring strategy in Canada.

[27] It is recognized that this is an issue for PM rather than ozone.

8.0 Benefits of Lower Levels of PM and Ground-Level Ozone

8.1 Information Summary

Effective decision making requires due consideration of the costs and benefits of undertaking action. "Benefits analysis" helps decision makers predict how particular actions might achieve a desired goal. It can help determine how costs and benefits are currently distributed across society and provide direction on how these might be justly re-allocated by undertaking certain actions.

The literature reviewed by the Multi-Stakeholder Group indicates that reductions in the ambient concentrations of particulate matter and ground-level ozone would likely have beneficial human health effects and that such benefits should be considered in establishing a Canada-Wide Standard for these substances. Thus, the Group sought information on predicted human health and environmental benefits of reductions in the ambient concentrations of particulate matter and ground-level ozone.

The MSG used information produced by a model developed for the Canadian Council of Ministers of the Environment. The "Damage Function Approach" in the Air Quality Valuation Model (AQVM) incorporates several types of data to estimate the avoided events associated with reductions in ambient concentrations of (in this case) particulate matter and ground-level ozone. The model also estimates monetized value for avoided damages. Data used include:

- air quality baseline and changes by location, time period, air pollutant;
- population data by location and time period;
- concentration-response functions for health, welfare, and environmental endpoints;
- monetary valuation for each endpoint;
- aggregation and discounting procedures;
- treatment of statistical uncertainty and unquantified omissions, biases, and uncertainties; and
- sensitivity analyses.

8.2 MSG Discussion

Due to the limitations noted in the Caveats section of this report, the work of Environment Canada with the AQVM was the only source of benefits information the MSG was able to consider. Several issues were discussed by the MSG, which raise concerns about the results produced by the model. These issues fell into three main categories:

- scientific issues regarding uncertainties about the role that chemical composition of particulate matter plays in producing a toxic effect;
- technical issues with the AQVM and its quantification of benefits; and
- ethical issues about whether this information should be used, even if reliable monetization of human health effects can be achieved and, if so, in what manner.

The MSG is also aware of work underway by the Royal Society's Expert Review Panel.[28] This panel was formed to conduct an objective and independent review of methods used to estimate and compare the costs and benefits of particulate matter and ozone reduction. The panel's report is scheduled for completion in the summer of 2000.

[28] More information, including the panel's terms of reference, can be found on the website of the Network for Environmental Risk Assessment and Management at http://www.neram.ca/Pages/research/royalsoc.htm

8.3 Data Gaps

The results of the AQVM model runs and further details regarding the MSG's concerns are noted in Appendix H.

8.4 Recommendations

The Multi-Stakeholder Group recommends that:

19. Alberta Environment track the work presently underway at the US Environmental Protection Agency, continuing the assessment of particulate matter.
20. research be undertaken to validate the association between human health effects and ambient concentrations of PM_{10} and $PM_{2.5}$.
21. Environment Canada be approached to provide any available information on the ecological benefits of reduced levels of particulate matter or ozone pollution.
22. Alberta Environment investigate and review the "Quality-Adjusted Life Years" approach to benefit assessment for consideration in policy decisions.

23. The MSG further recommends that the Group evaluate the forthcoming report of the Royal Society's Expert Review Panel and determine if additional recommendations are needed.

9.0 Costs of Control Technologies

9.1 Information Summary

In May 1999 the CCME Development Committee (DC) published estimates of the control costs to achieve various CWS scenarios. These estimates are currently being reviewed and revised by Environment Canada. The detailed costs were considered *preliminary* estimates for "across-the-board" percentage emission reductions from the 1995 emission inventory numbers for the sectors emitting the top 95% of emissions of PM_{10}, $PM_{2.5}$, SO_2, NOx and VOCs within each province or territory. Although the estimates considered emissions from key sectors, and assumptions were made to narrow the field and size of control technologies, there is no evidence that control technologies and costs are compatible with actual Alberta sources.

The MSG recognized the shortcomings of these estimates and commissioned a review of control technologies and costs that would better reflect the Alberta situation. Unfortunately the results of the review were not available for this report and the original DC estimates (May 1999) are presented as the only information available. The reader is cautioned to view these as rough estimates, for scoping purposes only.

The method used by the DC to estimate costs of achieving different optional CWS levels is described in the Development Committee's Discussion Document,[29] and summarized briefly here:

1. The reduction in ambient levels of PM and Ozone required to achieve optional CWS scenarios was estimated. (see Appendix I, Table I-1)
2. The size of emission reductions required to meet the optional CWS scenarios was estimated using assumptions about the relationship between overall emissions and ambient levels.
3. Cost tables were prepared for the cost of reducing the five target pollutants by 25%, 50% and 75% from the 39 source sectors contributing 95% of the emissions of these pollutants.
4. Cost estimates for reducing each of the five target pollutants by the percentages determined in Step 2 were extracted from the cost tables generated in Step 3.
5. From the range of optional cost estimates provided in Table 9.1, the incremental costs involved in reaching each successive optional CWS level for PM and ozone were determined. Incremental and total costs for Canada and Alberta are presented in Tables 9.2 and 9.3 for PM and ozone, respectively.

[29] Canada-Wide Standards Development Committee. May 1999. *Discussion Paper on PM and Ozone: Canada-Wide Standard Scenarios for Consultation.*

Table 9.1. Estimated Costs of Achieving Optional Combinations of PM and Ozone CWS Levels [30]

PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	Ozone (ppb)	Alberta ($M/yr)	Canada ($M/yr)
70	35	70	72	962
70	35	65	200	2,043
60	30	65	300	2,494
50	25	65	440	3,471
50	25	60	670	8,102
50	25	55	850	>19,260[31]
40	20	55	1,240	>>22,130[32]

Table 9.2. Estimated Incremental Costs of Achieving Optional PM CWS Levels [33]

24-h, 98th % $PM_{10}/PM_{2.5}$ ($\mu g/m^3$)	Alberta ($M/yr)*	National ($M/yr)
70/35	**0**	**170**
70/35 → 60/30	*100*	*451*
60/30	**100**	**620**
60/30 → 50/25	*140*	*977*
50/25	**240**	**1,600**
50/25 → 40/20	*390*	*>2,870*
40/20	**630**	**>4,470**

Table 9.3. Estimated Incremental Costs of Achieving Optional Ozone CWS Levels[34]

8-h, 4th Highest Ozone Level (ppb)	Alberta ($M/yr)*	National ($M/yr)
70	**72**	**790**
70 → 65	*128*	*1,071*
65	**200**	**1,871**
65 → 60	*230*	*4,631*
60	**430**	**6,502**
60 → 55	*180*	*>11,158*
55	**610**	**>17,660**

* Some errors may be present in Alberta data due to rounding

[30] Ibid

[31] > signs indicate costs would be greater than the numbers shown since cost estimates could not be made for the full emission reduction levels required to achieve that particular CWS option.

[32] >>signs indicate costs would be much greater than the numbers indicated.

[33] Canada-Wide Standards Development Committee. May 1999. *Discussion Paper on PM and Ozone: Canada-Wide Standard Scenarios for Consultation*

[34] Ibid

9.2 MSG Discussion

The MSG reviewed the cost estimates provided by the CCME Development Committee and identified a number of shortcomings. The control technologies and costs were obtained from a US EPA database that contained only the most basic information. The economic component of the database included cost-effectiveness data (i.e., "dollar per ton of emission reduced"). These cost-effectiveness values were derived by dividing annualized costs by the yearly expected emissions reduction of each pollutant. However, capital, operating and maintenance costs were not provided and it has been reported that the annual discount factor used to calculate the annualized costs was not consistent throughout the database. In addition, technology recovery efficiencies for control technologies were not provided.

As this was a scoping exercise no attempt was made to assess the compatibility of the control technologies with existing Alberta source sector processes. Thus, it is very unclear if the controls considered would provide the emission reductions estimated and it is also unclear as to how accurate the cost estimates really are.

The MSG therefore decided to commission a more detailed review, which is expected to be publicly available by the end of 1999. The gaps noted below were identified during this review.

9.2 Data Gaps

The MSG noted that data gaps exist in the following areas:

- There is no comprehensive list of processes in each Alberta source sector that emit particulate matter and precursors of PM and ozone.
- An understanding of control technologies compatible with the processes used by Alberta source sectors is needed.
- More information is needed on the reduction capabilities (and efficiencies) of compatible control technologies.
- An accurate estimate of the cost of control technologies for Alberta source sectors is needed.

9.4 Recommendations

The MSG recommends that Alberta Environment take the lead in:

24. establishing and maintaining a database that contains key process information about Alberta source sectors that emit particulate matter, and PM and ozone precursors.
25. identifying control technologies that are compatible with Alberta source sector processes.
26. identifying capital and operating and maintenance costs for compatible control technologies.
27. establishing a process to periodically review and update this information.
28. engaging Alberta source sectors and other stakeholders throughout the development of these cost estimates.

29. The MSG further recommends that the Group evaluate the forthcoming report on control technologies and costs for Alberta and determine whether additional recommendations are needed in this area.

10.0 Management Options

10.1 Information Summary

As part of its task, the Multi-Stakeholder Group identified management options that could be considered in overall emission reduction strategies to decrease ambient levels of PM and ozone. In the following text, "Management Options" refers to all emission reduction actions that were not previously addressed in the discussion of control technology options, although the examples illustrated in Appendix J do include some control technology options. Management options:

- include initiatives undertaken by the private sector as well as initiatives undertaken by any of the three levels of government (provincial, municipal and national);
- can be compulsory or voluntary in nature;
- apply at different levels (e.g., point source, local area, province-wide, or national); and
- cover different emission source sectors (transportation, construction, and so on).

Given this wide definition, a very large number of potential actions could be considered under this heading. Meaningful options can only be defined once there is an understanding of the extent and nature of the problem to be solved through these actions, as well as the scale, cost and effect of the measures themselves.

Ambient air quality varies across Alberta, due in part to the different pollution sources that contribute to local and regional air quality. Projected future trends in emissions will also reflect geographic differences, and will thus require different emission reduction strategies. Potential management options form a "shopping list" from which relevant items can be selected to meet the special needs of each area.

At this stage in the Alberta process it is impossible to be definitive about the type or nature of management options that might form part of emission reduction plans. Appendix J contains general examples of measures that have been identified in other jurisdictions.

10.2 MSG Discussion

The Group's discussion of management options was limited. However, there was general agreement that: a) action needs to be taken now to reduce emissions that affect air quality, in order to protect human health; and b) air quality issues in Alberta should be considered at both the airshed level and on a province-wide basis. Plans and activities at the airshed level could include, but not be limited to:

- identification of sources;
- identification of the gap between CWS and current ambient levels of PM and ozone;
- development of a comprehensive inventory of existing programs and initiatives;
- inclusion of existing programs and initiatives, where appropriate; and
- development and evaluation of new initiatives as necessary

10.3 Data Gaps

No analysis has been carried out to date on administrative measures. An evaluation process and clear criteria will be needed to compare all potential emission reduction options – both Control Technology and Administrative – and to identify promising candidates for inclusion in emission reduction plans. Factors to consider might include:

- effectiveness at reducing emissions (both locally and downstream);
- feasibility;
- cost;
- timeliness;
- impact on stakeholders (public, consumers, governments, industry, etc.); and
- public acceptance

The MSG also noted that there is presently no process in place to identify needed air quality improvements and to develop plans to implement these improvements in Alberta's major urban centres.

10.4 Recommendations

While some actions can be taken within the province or nation-wide, every region of Alberta will have different air quality levels and emission sources. To deal with these differences, the MSG recommends that:

30. Alberta Environment take the lead and involve stakeholders in developing a provincial strategy to reduce emissions of particulate matter and precursors to PM and ozone.
31. the Alberta Government actively encourage and support the formation of airshed management zones in Alberta. In doing this, Alberta Environment should play a facilitative, supportive and monitoring role to ensure that existing zonal experience is effectively shared.
32. airshed management zones set up a process, including consultation with stakeholders, to develop, file and participate in the implementation of action plans to achieve the Canada-Wide Standards for Particulate Matter and Ozone.
33. Alberta Environment promote the use and formation of airshed management zones for other provinces within the national process.
34. Alberta Environment be established as the organization ultimately accountable for compliance with the Canada-Wide Standards across the province.
35. Alberta Environment, in consultation with stakeholders, continue to identify and evaluate administrative options (that is, non "command and control" options) for reducing emissions of particulate matter and ozone.

11.0 Education

11.1 Information Summary

One of the objectives of the Multi-Stakeholder Group was to evaluate various education approaches as a way of informing the public about particulate matter and ozone. However, time to assess and discuss specific types of educational management options was very limited and additional work remains to be done in this area.

Various education and public information programs for PM and ozone do exist. For example, Alberta Environment supplies material to support environmental education programs and offers workshops to Alberta teachers; other stakeholders, including environmental organizations, health and energy departments, and industry also undertake public education activities.

Sources of educational material on PM and ozone include:

- CASA fact sheets and newsletters;[35]
- Environment Canada's website;[36]
- other provincial and regional Environment Departments: British Columbia, Greater Vancouver Regional District, Ontario; and
- website of the Canadian Council of Ministers of the Environment.[37]

11.2 MSG Discussion

The MSG recognizes that education is a useful tool, it is economically sound, and it follows the principle of pollution prevention.

It has been suggested that a comprehensive public education program is needed to address a variety of air issues, but this will require additional funding. Two issues must be covered by education programs for PM and ozone: the impacts of these two substances, and actions that can be taken by the average person to reduce emissions of PM and ozone.

11.3 Data Gaps

Because the MSG was unable to spend much time on education management options, the data gaps surrounding these options have not been fully documented.

11.4 Recommendations

The MSG recommends that:

36. opportunities for educating the public about PM and ozone be identified, further investigated and evaluated.
37. more effort be given to researching the possibility of combining PM and ozone education with other air quality topics that are more likely to be in the public eye (such as greenhouse gases).

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[35] CASA's URL is: www.casahome.org
[36] Environment Canada's URL is: www.ec.gc.ca
[37] CCME's URL is: www.mbnet.mb.ca/ccme/

12.0 Forecasts and Future Growth

12.1 Introduction

The Multi-Stakeholder Group had among its objectives to "define [the] 'future,' to forecast emissions for PM and ozone, and to develop actions for the future." These three topics are discussed in sections 12.1.1, 12.1.2, and 12.1.3 respectively.

12.1.1 Defining the Future

The definition of "future" varies according to opinion. Due to rapid changes in technology, most people see the future as faster computers, better cars, and more TV channels.[38] Individual predictions cover a wide variety of topics, three of which address the change in population, the changes in transportation, and the changes in energy demand.

Although predictions of the future always have varying degrees of uncertainty, one prediction seems highly likely to occur: Alberta's population will continue to grow. According to Statistics Canada, the nation's population is expected to increase from 29.9 million people in 1996 to 35.4 million in 2011 and to 37.1 million in 2016.[39] As the population increases over the next few years, so will the services and resources required to support it. As transportation and energy demand increase, so will levels of particulate matter and ozone.

Transportation will be different in the future, and demographic factors will play an important role in planning for and influencing these changes. For example, the City of Edmonton[40] predicts that suburban growth, an ageing population and a smaller school-aged population will affect transportation patterns. The size and distribution of population growth is predicted to lead to more decentralized travel patterns, as well as more and longer trips. Decentralized travel patterns, coupled with demographic changes will tend to make public transit service a somewhat less attractive travel option. Edmonton's population is expected to increase by about a third by 2020, while it is predicted that rush hour congestion will more than triple. If current trends continue, growth in traffic and congestion will result in only modestly higher vehicle emission levels, due to ongoing technological improvements in vehicle design.[41]

Energy demand is also likely to change in the future. Projections for Alberta's energy demand made by the Alberta Energy and Utilities Board, by Natural Resources Canada (NRCan), and by the National Energy Board seem to be in reasonable agreement.[42] Estimates by NRCan for each sector are given as a percentage of growth relative to energy demand in 1990. The residential sector shows the best performance, with only 0.99% growth. In other words, this sector is predicted to stay just below 1990 levels. Substantial increases are projected in energy demand in the Fossil Fuel Production sector (1.42% growth relative to 1990 levels), Transportation (1.39%), and Industry (1.79%).[43] Predictions have also

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[38] P. Dixon. "Searching for a Future." Article first published in Sunday *Telegraph*, January 11, 1998, found on Internet site http://www.globalchange.com/market.htm

[39] Statistics Canada Website. 1999. http://www.statcan.ca/english/Pgdb/People/Population/demo23a.htm

[40] City of Edmonton. 1999. Master Transportation Plan. City of Edmonton Internet site: http://www.gov.edmonton.ab.ca/transportation/master.htm#top

[41] Ibid.

[42] M. English. 1998. *Toward a Desired Future for the Year 2020: Projections for Alberta*. Clean Air Strategic Alliance. November 5, 1998.

[43] Ibid.

been made for two of the factors that affect energy demand: energy prices and weather conditions.[44] There is considerable variance in price projections, and there are at least two conflicting predictions about the weather.[45] Natural Resources Canada's energy demand calculations assume a "continuation of the average trends in temperature observed over the period 1980 to 1995."[46] Yet, Jacques et al found a 6.7% increase in energy demand in the residential sector and an increase of 4.9% in the commercial sector, in the period 1990 to 1996, due to weather.[47]

12.1.2 Forecasting Emissions for Particulate Matter and Ozone

The latest available forecast of criteria pollutants was issued from the National Emissions Inventory and Projections Task Group (NEIPTG) of the National Air Issues Coordinating Committee in March 1996. The period for this forecast is 1990 to 2010, with 1990 being the base year (actual emission estimates), and the years from 1995 to 2010 being forecasted years. A comparison of the recently released 1995 emission estimates to the forecasted 1995 numbers shows some distinct differences, due mainly to different estimation methodologies. This forecast, expected to be updated by the NEIPTG, will have 1995 as the base year, with forecasts every five years to the year 2015. The updated methodologies will be used in the new forecast.[48]

Some of the highlights of the forecast for Canada's emissions are given below.

Nitrogen Oxide (NOx)

- The Transportation sector accounted for 59% of NOx emissions in 1990 but is reduced by 11% over the forecast period due to improved standards for on-road vehicles.
- Emissions from Industrial Sources grow by 40% to the year 2010 from 489 Kt to 685 Kt due largely to increased economic activity and industrial fuel use.
- The remaining sectors – Power Generation, Non-Industrial Fuel Combustion and Incineration/Miscellaneous/Other – constitute the remaining 17% of 1990 emissions, and increase by 6% to the year 2010.

Volatile Organic Compounds (VOCs)

- 91% of 1990 emissions are produced by three sectors: Incineration/Misc/Other (33%), Industrial Sources (30%) and Transportation (28%).
- Emission levels for both the Incineration/Misc/Other and Industrial Source sectors grow over the forecast period by 20% and 14% respectively, while emissions from the Transportation sector show a decrease of 25%.
- The remaining two sectors, Non-Industrial Fuel Combustion and Power Generation, account for 9% and less than 1% of 1990 VOC emissions, and decrease slightly to the year 2010.

Sulphur Dioxide (SO_2)

- Canadian SO_2 emission levels decrease to the year 2010 by 13% from 3,305 Kt to 2,867 Kt due largely to the Federal/Provincial Agreements outlined in the "Eastern Canada Acid Rain Agreement, 1994."

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[44] M. English. 1998. *Toward a Desired Future for the Year 2020: Projections for Alberta*. Clean Air Strategic Alliance. November 5, 1998.
[45] Ibid.
[46] Natural Resources Canada. 1996. *Canada's Energy Outlook 1996-2020*.
[47] A. Jacques, F. Neitzert, and P. Birleau. 1997. *Trends in Canada's Greenhouse Gas Emissions (1990-1995)*. Environment Canada.
[48] Dave Slubik, Alberta Environment, material prepared for the Multi-Stakeholder Group, January 29, 1999.

- The Industrial Sources sector accounts for 75% of total SO_2 emissions and is reduced by 11% over the forecast period.
- The largest reduction in emissions occurs in the Power Generation sector, which decreases by 24% to the year 2010, reducing its portion of total SO_2 emissions from 21% to 18%.
- The three remaining sectors (Transportation, Non-Industrial Fuel Combustion and Incineration/Misc/Other) account for only 6% of 1990 SO_2 emissions and remain constant over the forecast period.

Forecasts for Alberta emissions show a modest growth in SO_2 and VOC emissions, with somewhat more accelerated growth in NOx emissions. Table 12.1 shows the predictions of emissions for criteria contaminants for Alberta and Canada, as prepared by the NEIPTG (March 1996). The 1990 emissions inventory was the base case, and numbers were forecast for 1995 to 2010.

Table 12.1. NAICC Consensus Forecast by Province[49]

(Kilotonnes)					
	1990*	**1995**	**2000**	**2005**	**2010**
NO_X					
Alberta	**487**	495	525	543	548
Canada	**2106**	1999	2080	2121	2187
VOC					
Alberta	**707**	720	718	735	755
Canada	**2829**	2679	2682	2782	2915
SO_2					
Alberta	**567**	637	554	565	589
Canada	**3305**	2805	2802	2854	2867

*1990 emissions are used as the base year, estimates for 1995-2010 are forecasts

Note: These forecasts present the result of a series of inputs, verifications and consultations of federal/provincial governments, private industry, and other non-government organizations toward the ultimate goal of a set of national consensus forecasts of air emissions of NOx, VOC and SO_2. The forecast calculations were based on the 1990 inventory of common air contaminants contained in the Residual Information Discharge System (RDIS) Version 02B.

12.1.3 Actions for the Future

The MSG did not discuss future actions in detail. However, the Group made some recommendations that relate to future growth and forecasts, and these are noted in Section 12.4.

12.2 MSG Discussion

The MSG did not discuss forecasts and future growth in detail. However, it recognized that growth in Alberta's population, transportation and energy demand will affect PM and ozone emissions. It is important to consider these issues in some depth when developing implementation plans for the CWS and when developing Alberta guidelines for PM and ozone.

[49] Source: Pollution Data Branch, Environment Canada, NAICC Consensus Forecast. March 1996

12.3 Data Gaps

English has provided a good description of some of the gaps in the data used for forecasting future growth.[50] With respect to access to data, most data comes from government sources and from published reports. The information in the reports is most likely already out of date by the time it is published. There likely is more, and better, information available that could not be collected in the time available. There are also deficiencies in the Criteria Pollutants Data, in that one cannot derive trends from the inventory data because different methodologies are used in each Criteria Air Contaminants Inventory.

12.4 Recommendations

The MSG recommends that:

38. the forecasts for population, transportation and energy demand be considered by Alberta Environment and by stakeholders when developing jurisdictional action plans to implement the Canada-Wide Standards for Particulate Matter and Ozone.
39. Alberta Environment and stakeholders collaborate on researching new estimates for future growth and forecasts in Alberta.

[50] M. English. 1998. *Toward a Desired Future for the Year 2020: Projections for Alberta.* Clean Air Strategic Alliance. November 5, 1998.

13.0 Stakeholder Positions on Standards for PM and Ozone

In addition to its other tasks, the Multi-Stakeholder Group strived to reach consensus on the level, form and timing of the Canada-Wide Standard and the Alberta Objective that should be established for particulate matter and for ozone. Although there were a number of areas of agreement, there was no consensus on level, form and timing of the standards. The various stakeholder positions on the level, form and timing of standards are presented below, along with a summary of key discussion points, including areas where the group had consensus, areas in which consensus was lacking, and areas in which more discussion is required.

Table 13.1. Stakeholder Positions on Level, Form and Timing of Standards for PM and Ozone

	Industry	ENGO	Health 1	Health 2	Municipality
PM_{10}					
Level	deferred in favour of an action plan	three steps: 50, 40, 25 $\mu g/m^3$	deferred until more information is available		70 $\mu g/m^3$
Form	$\mu g/m^3$, 24-hr and annual target, 98th percentile, averaged over 3 years	24-hour			24-hr, 98th percentile, "interim," annual <US level
Timing	2015	2005, 2010, 2015	obtain info by 2003, set number by 2005		2005
$PM_{2.5}$					
Level	deferred in favour of an action plan	three steps: 25,20,15 $\mu g/m^3$	deferred until more information is available		30 $\mu g/m^3$
Form	$\mu g/m^3$, 24-hr, 98th percentile averaged over 3 years; annual number as well	24-hour			24-hr, 98th percentile, "interim," annual <US level
Timing	2015	2005, 2010, 2015	obtain info by 2003, set number by 2005		2005
Ozone					
Level	two steps: 70-75 ppb, 65-70 ppb	two steps: 60 ppb, 40 ppb		50 ppb	70 ppb
Form	4th highest annually, averaged over 3 years, 8-hr Caveat: it depends on Alberta achievability. From an Alberta perspective, 1-hr may make more sense	1-hr maximum		6- or 8-hr	8-hr, but 1-hr may be more appropriate
Timing	2005, 2010-2015	2005, 2010		2005	2005

The Group agreed on the following points:

- The key driver for a Canada-Wide Standard (CWS) should be human health impacts.
- CWS levels should be reviewed periodically.
- The form should be an ambient concentration.
- There should be a 24-hour standard for PM, provided the daily level is acceptable.
- A mechanism is needed to deal with naturally occurring events.
- National and regional action plans should be developed and should include emission reduction strategies and recommendations for research on:
  - the relationship and contribution of indoor and outdoor contaminants;
  - personal exposure;
  - the toxic component of PM; and
  - naturally occurring background levels of ozone.

The Group was not able to reach consensus on:

- an attainment date for reaching the standards;
- the form the standard should take (e.g., maximum, percentile, and how to deal with natural events); and
- the level for PM and ozone.

There was agreement to have further discussion on:

- the implications of fence-line application vs. other applications of the standard;
- whether the CWS for ozone should be one-hour or eight-hour averages;
- the role of compliance in implementing the standards; and
- the need for a standard for PM_{10}.

14.0 Implementation

14.1 Information Summary

The MSG did not have time to develop an independent list of recommended future actions for reducing emissions of PM and ozone. However, the Group was involved in the May 1999 National Multi-Stakeholder Consultation Workshop hosted by the PM and Ozone CWS Development Committee, which generated a number of possible actions. This list of potential actions is attached as Appendix K for illustrative purposes only and does not indicate endorsement by the MSG.

The MSG noted that a number of initiatives currently exist in Alberta. Among those initiatives planned and underway is a workshop to address data issues. The objectives are to prioritize the data and information gaps, and to develop recommendations on: actions to fill gaps, actions to improve access to and use of data, and integration of data sets.

14.2 MSG Recommendation

The MSG recommends that:

40. Alberta Environment, with the assistance of the MSG, develop implementation plans for the PM and Ozone Canada-Wide Standards.

Appendix A. The Multi-Stakeholder Group on Particulate Matter and Ozone: Members, Terms of Reference, Milestones and Meetings

Members of the Multi-Stakeholder Group

Dana Atwell	CPPI/Shell Canada Products Limited
Alan Brownlee	City of Edmonton
Jim Dixon	Nova Chemicals/CCPA
Wes Dolhun	Inland Cement
Long Fu	Alberta Environment
Geoff Granville	Shell Canada Limited/CAPP
Kerra Hunt	Alberta Environment
Brian Hudson	Alberta Resource Development
Myles Kitagawa	Toxics Watch Society of Alberta
Martha Kostuch	Prairie Acid Rain Coalition
Ingrid Liepa	TransAlta Utilities
Christine Macken	Clean Air Strategic Alliance
Alexander MacKenzie	Alberta Health and Wellness
George Murphy	Alberta Environment
Sheldon Roth	Alberta Lung Association/University of Calgary
Neil Shelly	Alberta Forest Products Association
Kent Stuehmer	Inland Cement
James Tweedie	Bert Riggall Environmental Foundation
Srikanth Venugopal	TransCanada Transmission/Canadian Energy Pipeline Association

Former Members:

Tee Guidotti	Alberta Lung Association/University of Alberta
Brent Lakeman	Alberta Resource Development
Joe Ruggiero	Alberta Resource Development

Corresponding Members:

Dermot Lane	Fording Coal Limited
Tom Marr-Laing	Pembina Institute
Doug Smith	Canadian National
Dave Reynolds	City of Calgary
Collin Heath	Alberta Trucking Association

Terms of Reference

Purpose

- To provide advice (input) to Alberta Environment on:
  - the development of PM and Ozone Canada-Wide Standards, and
  - the development of Alberta PM and Ozone ambient air quality guidelines; and
- To report to the CASA Board of Directors.

Objectives

For PM and Ozone:

1. to provide input to the Canada-Wide Standards development process
2. to recommend the level, form and application of Alberta guidelines
3. to recommend the plan of action by which guidelines/standards will be pursued

Key deliverables/Anticipated Results

1. Multi-Stakeholder Group advice to Alberta Environment at various stages of consultation
2. Technical reports to Alberta Environment resulting from the consultation process
3. Final recommendations to Alberta Environment by the Multi-Stakeholder Group
4. Multi-Stakeholder Group report to CASA Board of Directors

Milestones of the Multi-Stakeholder Group for PM and Ozone (MSG)

Jan. 29, 1998	The CCME (except Quebec) signed the Harmonization Accord.
Feb. 20, 1998	Alberta Environment asked the CASA Board to establish a Multi-Stakeholder process and to receive recommendations on stakeholders.
Mar. 18, 1998	CASA Board of Directors approves Alberta Environment's proposal.
Apr. 7, 1998	MSG Meeting #1, Edmonton.
Jul. 16, 1998	MSG Terms of Reference approved.
Sept. 22, 1998	Draft MSG Work Plan.
Oct.14-16, 1998	First National Consultation Workshop, Toronto, eight MSG members attended.
Nov. 16, 1998	Draft budget. MSG members contribute about $40,000 to support proposed projects.
Dec. 4, 1998	Draft Communication Strategy.
Jan. 13, 1999	MSG Workshop, Edmonton. Identified near-term priorities among the master work plan tasks and the links with the national process.
Feb. 25, 1999	Approved terms of reference and initiated contract work for Source Apportionment and Ambient Data Collection and Analysis. Approved the coordinates of 11 Regions in Alberta for Air Quality Review.
Apr. 26, 1999	Revised the work plan and identified significant information gaps in preparation for the National Workshop May 26-28 in Calgary.
May 26-28, 1999	Second National Consultation Workshop, Calgary; ten MSG members attended.
June 14, 1999	Received initial results from the contract work for Source Apportionment and Ambient Data Collection and Analysis. Began drafting MSG's Final Report.
Oct. 22, 1999	MSG sign-off on report to Alberta Environment.
Dec. 7, 1999	Final MSG meeting. MSG De-briefing.

Meeting Record of the Multi-Stakeholder Group for PM and Ozone

Apr. 7, 1998	**MSG Meeting #1**, CASA Office, Edmonton.
May 4, 1998	**MSG Meeting #2**, Provincial Building, Red Deer.
Jun. 5, 1998	**MSG Meeting #3**, Provincial Building, Red Deer.
Jul. 16, 1998	**MSG Meeting #4**, CASA Office, Edmonton.
Aug. 27, 1998	MSG Teleconference.
Sept. 11, 1998	**MSG Meeting #5**, Shell Office, Calgary.
Nov. 2, 1998	**MSG Meeting #6**, CASA Office, Edmonton
Nov. 16, 1998	**MSG Meeting #7**, Teleconference.
Dec. 4, 1998	**MSG Meeting #8**, Provincial Building, Red Deer.
Jan. 7, 1999	MSG Teleconference.
Jan. 13, 1999	MSG Workshop, Inn on 7th, Edmonton.
Feb. 4, 1999	**MSG Meeting #9**, Teleconference.
Feb. 25, 1999	**MSG Meeting #10**, Shell Canada Building, Calgary.
Apr. 26, 1999	**MSG Meeting #11**, CASA Office, Edmonton.
May 20, 1999	MSG Teleconference.
Jun. 14, 1999	**MSG Meeting #12**, TransCanada Building, Calgary.
Jul. 15, 1999	**MSG Meeting #13**, Teleconference.
Aug. 26, 1999	**MSG Meeting #14**, Teleconference.
Sept. 15, 1999	**MSG Meeting #15**, CASA Office, Edmonton
Oct. 15, 1999	**MSG Meeting #16**, Teleconference.
Oct. 22, 1999	**MSG Meeting #17**, CASA Office, Edmonton.
Nov. 3, 1999	MSG Teleconference.
Nov. 8, 1999	MSG Teleconference.
Dec. 7, 1999	**MSG Meeting #18**, Shell Canada Building, Calgary.

Appendix B. Additional Documents

To support the Multi-Stakeholder Group in its work, Alberta Environment commissioned the following studies:

Alberta Research Council. 1998. *Overview on Particulate Matter*. Prepared for Alberta Environmental Protection and Stakeholders.

Hiltz, Michelle and Abdel Kharrat. 1999. *Alberta Source Apportionment Study*. Report prepared for Alberta Environment and Stakeholders, Alberta Research Council, Vegreville.

Sandhu, H.S. 1998. *Ambient particulate matter in Alberta*. Report prepared for Science and Technology Branch, Alberta Environment. No. 1494-9805, Edmonton, Alberta.

Sandhu, H.S. 1999. *Ground-level ozone in Alberta*. Report prepared for Science and Technology Branch, Alberta Environmental Protection. No. 1494-A9901, Edmonton, Alberta.

The MSG commissioned the following studies:

Jacques Whitford Environment Limited. 1999. *Assessment of Cost Estimates for Canada-Wide Standards for PM and Ozone*. (in publication)

Levelton Engineering Ltd. 1999. *Alberta Ambient Particulate Matter and Ozone Monitoring Data Review*. Prepared for the Alberta Multi-Stakeholder Group for Particulate Matter and Ozone.

Appendix C. Communications Strategy for the Consultation on Canada Wide Standards for PM and Ozone

Issue

Under the CCME Harmonization Accord, signed in January 1998, the Canada-Wide Standards (CWS) for PM and Ozone are being developed. Alberta Environment is a member of the National Development Committee for PM and Ozone and is mandated under EPEA Section 14 to conduct public consultation.

Communications Objectives

- to share information on PM and ozone with Albertans – what they are, where they come from and the associated health risks and environmental effects – and why it is important to reduce emissions and ambient levels
- to demonstrate that the development and implementation of Canada-Wide Standards for PM and ozone is important to improving overall environmental quality
- to help the public understand the level, form, timeline and the implementation of PM and ozone CWS
- to inform the public of opportunities and mechanisms to provide input to the process.

Messages

- The development of Canada-Wide Standards is an important element of the national and provincial strategies to improve air quality and to better protect the environment and public health
- Federal-provincial cooperation is essential to achieving results on the development of Canada-Wide Standards.
- Consultations with the public and stakeholders will be undertaken to develop Canada-Wide Standards for PM and ozone
- Improving air quality is everyone's business. Through joint action, governments, industry, communities and individual Canadians, can improve the air we breathe

Target Audiences

- Stakeholder groups
- Municipal governments
- Academic, research institutes
- General public

Communications Opportunities

- post background information on the science, current levels, proposed approach on CCME, Alberta Environment, CASA web sites. Provide mechanism for feedback. Promote technological advancements by Canadian industries that are contributing to the reduction of PM and ozone precursor emissions. Release monitoring data updates to show reduction in emissions and ambient levels.
- Send letter and backgrounder to interested parties
- Public consultations

Products

- Fact sheet on progress of PM and Ozone CWS for web sites
- Q's and A's
- Speech modules
- Stakeholder list
- Information (tip) sheet item. Feature article for weeklies, industry trade magazines

YOUR INPUT IS REQUESTED

Alberta's environmental standards are among the highest in North America. To further refine these standards, Alberta Environmental Protection (AEP) is seeking public input in the development of Canada-wide standards for particulates and ground-level ozone. Particulate matter and ground-level ozone in the air have the potential to affect human health and the environment.

Public consultation is a key part of the standards development process. An Alberta multi-stakeholder group (MSG), which includes representatives from government, industry and environmental organizations, was formed in March 1998. The MSG provides advice to AEP on Alberta's role in developing standards for particulates and ground-level ozone. Standards for these two pollutants may have significant benefits and costs for Albertans.

For information about Alberta's contribution to the Canada-wide standards for particulates and ground-level ozone, or to receive a questionnaire for providing your input, please contact Alberta Environmental Protection at 780/427-0029 or to call toll free from anywhere in Alberta, dial 310-0000, then press zero and request the above phone number. Your requests can also be submitted by e-mail to PM.Ozone@gov.ab.ca. Additional information regarding Canada-wide standards is available on the Canadian Council of Ministers of the Environment (CCME) Website at http://www.mbnet.mb.ca/ccme/index.html.

Alberta
ENVIRONMENT

Appendix D. Airshed Regions and Boundaries as Defined by Alberta MSG on PM and Ozone (1999)

Airshed Boundaries as Defined by Alberta MSG on Particulate Matter and Ozone (1999)

1. West Central Zone

(same as the West Central Airshed Society (WCAS) boundaries)

North Boundary - Along top of Twp 54 from West of Range 6 to AB/BC Border

West Boundary - AB/BC Border

South Boundary - Top of Twp 42 from the BC Border to Hwy 20

East Boundary - North along Hwy 20 to West of Range 3, W5M
North along West of Range 3 to top of Twp 50
West along top of Twp 50 to West of Range 5
North along West of Range 5 to top of Twp 52
West along top of Twp 52 to West of Range 6
North along West of Range 6 to top of Twp54

2. Parkland Zone

(same as the Parkland Airshed Management Zone (PAMZ) boundaries)

North Boundary - Top of Twp 42

West Boundary - AB/BC Border

South Boundary - Top of Twp 27

East Boundary - Hwy 21

3. Southern Wood Buffalo Zone

(same as the Wood Buffalo Environmental Association (WBEA) boundaries)

North Boundary - Top of Twp 104

West Boundary - West of Range 18, W4M

South Boundary - Top of Twp 83

East Boundary - West of Range 5, W4M

4. Edmonton Region

North Boundary - Top of Twp 57

West Boundary - North along Hwy 20 to West of Range 3, W5M
North along West of Range 3 to top of Twp 50
West along top of Twp 50 to West of Range 5
North along West of Range 5 to top of Twp 52
West along top of Twp 52 to West of Range 6
North along West of Range 6 to top of Twp 54 (West Central)
East along Top of Twp 54 to S.Hwy 757
North along S.Hwy 757 to top of Twp 57

South Boundary - Top of Twp 42

East Boundary - Hwy 855

5. Calgary Region

North Boundary - Top of Twp 28 (PAMZ)

West Boundary - AB/BC Border

South Boundary - Top of Twp 20

East Boundary - Hwy 21 South to Hwy 1
Hwy 1 West to S.Hwy 817
S.Hwy 817 South to Hwy 24
Hwy 24 South to the Top of Twp 20

Abbreviations
Hwy = Highway
S.Hwy = Secondary Highway
Twp = Township

6. Southern Alberta Region

North Boundary - Top of Twp 20
West Boundary - AB/BC Border
South Boundary - AB/USA Border
East Boundary - AB/SK Border

7. Drumheller Region

North Boundary - Top of Twp 42
West Boundary - Hwy 21 South to Hwy 1
Hwy 1 West to S.Hwy 817
S.Hwy 817 South to the Top of Twp 20
South Boundary - Top of Twp 20
East Boundary - AB/SK Border

8. Wainwright/Lloydminster Region

North Boundary - Top of Twp 57
West Boundary - S.Hwy 855
South Boundary - Top of Twp 42
East Boundary - AB/SK Border

9. Grande Prairie/Peace River Region

North Boundary - Top of Twp 92
West Boundary - AB/BC Border
South Boundary - Top of Twp 54 (West Central)
North on S.Hwy 757 to the Top of Twp 57
Top of Twp 57 East to Hwy 33
East Boundary - Hwy 33 North to Hwy 2
Hwy 2 East to Hwy 88
Hwy 88 North to the Top of Twp 92

10. Athabasca/Cold Lake Region

North Boundary - Top of Twp 83
West Boundary - North on Hwy 33 to Hwy 2
Hwy 2 East to Hwy 88
North on Hwy 88 to the Top of Twp 83
South Boundary - Top of Twp 57
East Boundary - AB/SK Border

11. Northwest Region

North Boundary - AB/NWT Border
West Boundary - AB/BC Border
South Boundary - Top of Twp 92 to Hwy 88
South on Hwy 88 to Top of Twp 83
East along Twp 83 to West of Range 18, W4M
North along West of Range 18 to Twp 104
East along Twp 104 to West of Range 5, W4M
South along West of Range 5 to Twp 83
East along Twp 83 to AB/SK Border
East Boundary - AB/SK Border

Spatial Distribution of Emissions – Overview of the Methodologies[51]

Some methodologies related to the spatial distribution of emissions of criteria air contaminants for area sources have been significantly modified for the 1995 inventory year. Hence, the 1990 inventory data must be spatially re-distributed using these new methods so that the two inventory years can be compared. One of the most important sectors to be improved with the new techniques is 'transportation and related activities,' which includes sources such as road, marine, railroad and aircraft emissions.

Overview of Methodologies

For the 1990 inventory year, area source emissions were evenly distributed on a grid system, using a technique that prorated factors based on a few socio-economic statistics such as total population and dwellings, and on five major sectors of the labour force provided by Enumeration Areas. Since no adequate statistics could be assigned to many sectors, population was the factor most commonly used, which resulted in inconsistent spatial distributions. For example, since all road transportation emissions and dust were based on population, most transportation-related emissions came from populated areas, regardless of the road density and traffic. In fact, road traffic can be very dense along highways where no one lives. For the 1995 inventory, along with existing spatial modelling techniques related to socio-economic data, new methodologies were developed to increase the accuracy and the reliability of the spatially disaggregated provincial area source emissions. Also, the demand for emission estimates on a larger scale (such as by Census Metropolitan Areas or Urban Areas) was so significant that it created a need to obtain more detailed, accurate and up-to-date input data, as noted below:

- acquisition of a Canadian Road Network in a geographic format with corresponding attributes such as road class and surface typ.
- more detailed labour force statistics, with some 20 variables that permitted more flexibility in terms of linkage between labour force and the various sectors found in the 1995 inventory.
- Corridors and routes were identified and added to the spatial distribution process so that emissions from sources such as marine, aircraft, and railroads could be geographically allocated to specific areas rather than evenly distributed across the country.
- Forest fires locations for 1995 were included in the spatial distribution process enhancement.

Point source emissions are simply aggregated with the help of their geographic coordinates (latitude/longitude) and no further spatial distribution is performed. Point sources include industrial, commercial and institutional facilities, ports and airports.

Description of Methodologies

The basic methodologies used to create and process the grid system to be applied to the selected study area have remained more or less the same. Various grid sizes can be defined and generated depending on the user's specifications. National, provincial and regional maps are used as base maps to delimit study areas for which emissions will be calculated and distributed. Once the grid system is created, several attributes are calculated with the help of Geographic Information Systems (GIS) map and table modelling functionalities. Grid overlays with layers of various input data are also produced. Database linkage processing and calculations of emission estimates are usually executed in dBase since it allows more flexibility than the GIS table modelling functions.

New Spatial Components

Along with existing spatial information such as Enumeration Area maps and attributes, new geographic components (discussed below) were added to the spatial modelling of the 1995 inventory data.

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[51] Information provided by the Pollution Data Branch, Environment Canada, 1997.

The Canadian National Road Network

The road network is the basis on which emissions from road transportation and road dust are geographically distributed. The initial national road database consisted of a 1:1 million mapsheet containing road segments in a vector form with corresponding attributes such as the road class (highway, primary, secondary, street and limited-access road) and road surface (paved or unpaved). Provincial grid systems of 10 km by 10 km were created and road data and attributes were aggregated by grid cell. A 25 km by 25 km grid was created for the Northwest Territories, as its large land area would required extensive data processing when in fact there are few roads. The resulting gridded data consists of total road length in kilometres by road class and surface for each grid cell of each provincial grid system.

In order to reflect road surface conditions throughout the year and be able to distribute road dust when precipitation is absent, daily weather data were calculated for all provincial grid systems; total precipitation and total snow data were processed and combined through various dBase procedures. Periods of time when the snow covers the ground were assumed for each province. The provincial grid-aggregated weather data were then combined with the road information and processed in Visual dBase programs to: 1) calculate and distribute dust and fugitive emissions for paved and unpaved roads, and 2) distribute mobile emissions.

Resulting data consisted of database tables for each provincial grid system, containing total emissions of road dust, fugitive emissions and mobile emissions by individual grid cell. This output table is called the "Road Transportation Grid Network." To differentiate each type of emissions, a Source Industrial Code (SIC) is assigned to each record of information:

- 15111 => Tire Wear
- 45600 => Light Duty Gasoline Trucks
- 45601 => Heavy Duty Gasoline Trucks
- 45603 => Light Duty Diesel Trucks
- 45604 => Heavy Duty Diesel Trucks
- 45605 => Light Duty Diesel Vehicles
- 45890 => Gasoline Powered Automobiles
- 45891 => Gasoline Powered Motorcycles
- 45893 => Dust from Unpaved Roads
- 45911 => Dust from Paved Roads

For the 1990 inventory, area source emissions from road activities were spatially distributed using total population.

Marine Corridors

Area emissions from marine sources such as dockside areas, ferries and other activities are distributed along specific corridors instead of being evenly distributed over the study area. Two different types of corridors were generated to better distribute these emissions:

- provincial marine corridors for domestic and international movements defined by specific dockside areas that could not be represented by point locations, such as the East Coast of Vancouver Island, Québec/Lévis, etc. All area source emissions from dockside and associated activities are spatially allocated within these corridors. Delimitation of provincial corridors was based on provincial and international boundaries; the 200-mile limit was used as the international boundary.
- provincial ferry corridors that correspond to buffered "ferry routes" between two locations (ports); all emissions referring to ferry activities are distributed within these corridors.

For the 1990 inventory, area source emissions from marine activities were spatially distributed using total population.

Railroad Corridors

Area source emissions from railroad-related sectors such as rail transportation and the railroad rolling stock industry are distributed along railroad corridors across the country; 250-metre provincial buffers were generated from a dataset of the Canadian railroad network, regardless of the traffic movement, in order to confine emissions within specific boundaries. For the 1990 inventory, area source emissions from railroad activities were spatially distributed using total population.

Aircraft Corridors

Inflight area source emissions from aircraft are distributed within specific provincial flight corridors based on best-known flight routes and types of aircraft. Three different flight corridors were generated for the spatial distribution of emissions:

- corridors for heavy jets based on domestic and international aircraft movement from major airlines;
- corridors for light and medium jets based on domestic aircraft movement from major airlines; and
- 50-kilometre provincial buffers based on a dataset of minor airport locations.

For the 1990 inventory, area source emissions from aircraft activities were spatially distributed using total population.

Forest Fire Areas

Prescribed and open fires as well as forest fires from other forestry services were distributed within known burnt areas found in 1995 national forest fire coverage generated by combining forest fire datasets from provincial departments. Satellite imagery was used when no data were available from the provinces. For the 1990 inventory, emissions from forest fire activities were spatially distributed using total population.

GIS Processing

Various spatial overlays and attributes aggregations were performed within the GIS to obtain pre-processed input data to be further used in calculating emissions. These included:

a) generation of a grid system (grid points and grid map) based on grid size and study area;
b) calculation of grid cells area and centroids (latitude/longitude);
c) aggregation of 1995 inventory point source emissions by grid cells;
d) aggregation of other point source emissions such as dockside and airports (take-off and landing activities) by grid cells;
e) production of spatial information overlays of the grid system and geographic information:
   - Enumeration Area map with related socio-economic statistics
   - Railroad corridors
   - Forest fires polygons
   - Road Transportation Grid Network
   - Marine corridors
   - Ferry corridors
   - Aircraft flight corridors

Emissions Calculations

All emissions calculations were processed in dBase using database functionalities, spatially-processed information and the 1995 inventory data. The following section refers to the step-by-step procedures related to the emissions calculations.

a) generic calculations and distribution of area sources emissions for all sectors using socio-economic data. Below is a list of all statistics used in the emission calculations.

- total population
- total dwellings
- agricultural and related service industries
- fishing and trapping industries
- logging and forestry
- mining (including milling), quarrying and oil industries
- manufacturing industries
- construction industries
- transport and storage industries
- communication and other utility industries
- wholesale trade industries
- retail trade industries
- finance and insurance industries
- real estate operator and insurance agent industries
- business service industries
- government service industries
- educational service industries
- health and social service industries
- accomodation, food and beverage service industries
- other service industries
- all commercial (wholesale and retail combined)
- intersection of agriculture and manufacturing services
- intersection of forestry and manufacturing services
- intersection of mining and manufacturing services
- intersection of communication services and total dwellings
- intersection of government services and total dwellings

b) update of all road transportation emission estimates for road dust and mobile emissions;
c) update of marine emissions;
d) update of railroad emissions;
e) update of inflight aircraft emissions;
f) update of forest fire emissions;
g) addition of dockside and airport emissions; and
h) addition of emission information such as plants, docks and airport names and identifiers, report category and sector names and other information related to the grid cells such as centroids and area.

Appendix E. Alberta's Criteria Air Contaminant Emissions

December 1998

CATEGORY / SECTOR	PART	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
INDUSTRIAL SOURCES							
Abrasives Manufacture							
Aluminum Industry	0	0	0	2,419	227	0	0
Asbestos Industry							
Asphalt Paving Industry	2,840	426	142	0	0	0	0
Bakeries	0	0	0	0	0	313	0
Cement and Concrete Industry	1,788	465	124	3,094	7,638	36	277
Chemicals Industry	943	874	414	1,890	15,821	2,027	4,082
Clay Products Industry	312	22	1	0	0	0	0
Coal Mining Industry	5,706	4,048	3,067	2,336	1,337	589	56
Ferrous Foundries	74	70	65	0	1	1	699
Grain Industries	12,148	2,328	319	0	0	0	0
Iron and Steel Industries	7	6	6	81	92	1	16
Iron Ore Mining Industry							
Mining and Rock Quarrying	1,979	194	49	447	620	14	101
Non-Ferrous Mining and Smelting Industry							
Oil Sands	3,937	1,787	1,407	160,948	16,542	81	1,447
Other Petroleum and Coal Products Industry							
Paint & Varnish Manufacturing							
Petrochemical Industry	189	188	23	271	7,544	8,528	1,299
Petroleum Refining	833	832	832	15,232	3,956	755	1,044
Plastics & Synthetic Resins Fabrication							
Pulp and Paper Industry	2,088	1,874	1,770	3,840	4,430	43	1,909
Upstream Oil and Gas Industry	1,200	1,162	1,147	276,477	255,712	484,788	40,913
Wood Industry	28,735	15,517	10,029	1	4,857	11	296,787
Other Industries	10,770	8,683	6,543	234	8,667	309	7,191
TOTAL INDUSTRIAL SOURCES	**73,549**	**38,478**	**25,939**	**467,270**	**327,444**	**497,497**	**355,822**
NON INDUSTRIAL FUEL COMBUSTION							
Commercial Fuel Combustion	530	520	510	389	5,444	260	1,016
Electric Power Generation (Utilities)	9,665	8,973	8,777	130,471	90,734	1,101	7,972
Residential Fuel Combustion	1,156	904	835	317	6,365	511	2,866
Residential Fuel Wood Combustion	7,525	7,525	7,149	108	667	36,033	58,557
TOTAL NON INDUSTRIAL FUEL COMBUSTION	**18,876**	**17,922**	**17,270**	**131,285**	**103,211**	**37,905**	**70,411**
TRANSPORTATION							
Air Transportation	270	149	105	527	8,215	2,050	10,684
Heavy-duty diesel vehicles	4,682	4,682	4,319	2,352	61,577	8,178	38,037
Heavy-duty gasoline trucks	123	120	96	122	3,851	2,444	34,165
Light-duty diesel trucks	298	298	276	174	1,418	680	1,179
Light-duty diesel vehicles	27	27	25	13	124	49	103
Light-duty gasoline trucks	482	467	385	480	21,125	28,982	289,762
Light-duty gasoline vehicles	451	438	306	666	30,733	44,123	430,581
Marine Transportation	98	78	65	10	19	2,853	9,321
Motor cycles	2	2	1	2	63	171	1,173
Off-road use of diesel	5,264	5,264	4,843	3,720	51,910	5,608	16,326
Off-road use of gasoline	449	368	313	149	5,158	11,769	194,030
Rail Transportation	537	537	494	1,237	22,135	1,039	4,255
Tire wear & Brake lining	599	592	192	0	0	0	0
TOTAL TRANSPORTATION	**13,282**	**13,023**	**11,420**	**9,453**	**206,326**	**107,946**	**1,029,617**

CATEGORY / SECTOR	PART	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
INCINERATION							
Crematorium	0	0	0	0	2	0	1
Industrial & Commercial Incineration	21	16	11	7	13	3	5
Municipal Incineration							
Wood Waste Incineration	0	0	0	10	0	1,068	0
Other Incineration & Utilities							
TOTAL INCINERATION	**21**	**16**	**11**	**17**	**15**	**1,071**	**6**
MISCELLANEOUS							
Cigarette Smoking	57	57	57	0	0	1	270
Dry Cleaning	0	0	0	0	0	753	0
Fuel Marketing	0	0	0	0	0	9,678	0
General Solvent Use	0	0	0	0	0	26,584	0
Marine Cargo Handling Industry							
Meat Cooking	110	110	110	0	0	0	0
Pesticides and Fertilizer Application	2,396	1,174	335	0	0	0	0
Printing	0	0	0	0	0	2,633	0
Structural Fires	603	597	542	0	0	585	1,205
Surface Coatings	0	0	0	0	0	10,606	0
TOTAL MISCELLANEOUS	**3,166**	**1,937**	**1,045**	**0**	**0**	**50,840**	**1,476**
OPEN SOURCES							
Agriculture (Animals)	99,275	60,386	9,478	0	0	0	0
Agriculture Tilling and Wind Erosion	510,736	247,931	5,107	0	0	0	0
Construction Operations	831,976	183,035	3,705	0	0	0	0
Dust from Paved Roads	189,616	36,343	8,691	0	0	0	0
Dust from Unpaved Roads	3,242,466	921,577	138,803	0	0	0	0
Forest Fires	54,325	46,177	38,028	32	14,252	61,356	447,385
Landfills Sites	515	41	10	0	0	309	0
Mine Tailings	1,848	148	37	0	0	0	0
Prescribed Burning	15,757	13,457	9,420	43	2,070	5,808	96,152
TOTAL OPEN SOURCES	4,946,513	1,509,094	213,278	75	16,323	67,473	543,537
PROVINCIAL TOTAL	**5,055,407**	**1,580,470**	**268,963**	**608,100**	**653,319**	**762,732**	**2,000,869**

Source: Environment Canada 1998

Appendix F. Detailed Emissions Breakdown by Zones

1 WEST CENTRAL

1995 CAC EMISSIONS IN TONNES

SIC report name code	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Industrial Sources							
80	ASPHALT PAVING INDUSTRY	49	7	2	0	0	0	0
90	BAKERIES	0	0	0	0	0	5	0
110	CEMENT AND CONCRETE INDUSTRY	6	3	1	0	0	0	0
120	CHEMICAL INDUSTRY	6	6	6	0	83	1	15
140	CLAY PRODUCTS INDUSTRY	5	0	0	0	0	0	0
150	COAL INDUSTRY	704	428	290	1,397	907	309	56
210	FERROUS FOUNDRIES	1	1	1	0	0	0	12
260	GRAIN INDUSTRIES	274	52	7	0	0	0	0
300	IRON AND STEEL PRODUCTION	0	0	0	1	2	0	0
400	MINING AND ROCK QUARRYING	95	9	2	22	30	1	5
480	OTHER INDUSTRIES	1,066	918	753	5	198	28	667
600	PULP AND PAPER INDUSTRY	183	168	150	1,855	784	8	1,277
690	UPSTREAM OIL & GAS INDUSTRY	90	90	90	20,149	15,450	23,446	2,503
700	WOOD INDUSTRY	3,654	1,952	1,245	0	407	0	38,865
		6,132	**3,637**	**2,5**	**23,429**	**17,860**	**23,798**	**43,400**
	Non Industrial Fuel Combustion							
160	COMMERCIAL FUEL COMBUSTION	8	8	8	6	80	4	15
200	ELECTRIC POWER GENERATION	26	26	26	2	2,414	11	302
620	RESIDENTIAL FUEL COMBUSTION	20	15	14	5	107	9	48
630	RESIDENTIAL FUELWOOD COMBUSTION	127	127	121	2	11	608	988
		180	**176**	**168**	**15**	**2,613**	**632**	**1,353**
	Transportation							
40	AIR TRANSPORTATION	16	9	6	29	524	10	54
270	HEAVY-DUTY DIESEL VEHICLES	462	462	426	232	6,077	807	3,754
280	HEAVY-DUTY GASOLINE TRUCKS	11	11	9	11	343	218	3,047
330	LIGHT-DUTY DIESEL TRUCKS	26	26	24	15	125	60	104
340	LIGHT-DUTY DIESEL VEHICLES	2	2	2	1	11	4	9
350	LIGHT-DUTY GASOLINE TRUCKS	43	42	34	43	1,879	2,578	25,778
360	LIGHT-DUTY GASOLINE VEHICLES	41	40	28	60	2,777	3,987	38,904
380	MARINE TRANSPORTATION	2	2	2	0	0	66	216
410	MOTORCYCLES	0	0	0	0	5	13	87
450	OFF-ROAD USE OF DIESEL	90	90	83	64	888	96	279
460	OFF-ROAD USE OF GASOLINE	8	6	5	3	88	201	3,319
610	RAIL TRANSPORTATION	35	35	32	80	1,426	67	274
670	TIRE WEAR	54	54	17	0	0	0	0
		790	**778**	**668**	**538**	**14,143**	**8,107**	**75,825**
	Incineration							
180	CREMATION	0	0	0	0	0	0	0
710	WOOD WASTE INCINERATION	0	0	0	1	0	141	0
		0	**0**	**0**	**1**	**0**	**141**	**0**

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Miscellaneous							
130	CIGARETTE SMOKING	1	1	1	0	0	0	5
190	DRY CLEANING	0	0	0	0	0	11	0
230	FUEL MARKETING	0	0	0	0	0	140	0
250	GENERAL SOLVENT USE	0	0	0	0	0	451	0
385	MEAT COOKING	2	2	2	0	0	0	0
530	PESTICIDES AND FERTILIZER APPLICATION	54	26	8	0	0	0	0
580	PRINTING	0	0	0	0	0	45	0
650	STRUCTURAL FIRES	7	7	6	0	0	7	14
660	SURFACE COATINGS	0	0	0	0	0	180	0
		64	**36**	**17**	**0**	**0**	**833**	**18**
	Open Sources							
20	AGRICULTURAL OPERATIONS	11,504	5,584	115	0	0	0	0
30	AGRICULTURE	2,236	1,360	213	0	0	0	0
170	CONSTRUCTION	14,232	3,131	63	0	0	0	0
320	LANDFILL SITES	5	0	0	0	0	3	0
390	MINE TAILINGS	89	7	2	0	0	0	0
520	PAVED ROADS	10,325	1,848	478	0	0	0	0
680	UNPAVED ROADS	1,463,948	406,560	62,663	0	0	0	0
		1,502,338	**418,491**	**63,534**	**0**	**0**	**3**	**0**
	TOTAL	**1,509,504**	**423,118**	**66,936**	**23,983**	**34,616**	**33,514**	**120,597**

2 PARKLAND

1995 CAC EMISSIONS IN TONNES

SIC REPORT NAME CODE	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Industrial Sources							
80	ASPHALT PAVING INDUSTRY	204	31	10	0	0	0	0
90	BAKERIES	0	0	0	0	0	16	0
110	CEMENT AND CONCRETE INDUSTRY	17	9	3	0	0	0	0
120	CHEMICAL INDUSTRY	19	19	19	2	289	4	51
140	CLAY PRODUCTS INDUSTRY	16	1	0	0	0	0	0
150	COAL INDUSTRY	474	351	274	43	23	16	0
210	FERROUS FOUNDRIES	4	4	3	0	0	0	36
260	GRAIN INDUSTRIES	1,604	307	42	0	0	0	0
300	IRON AND STEEL PRODUCTION	0	0	0	4	5	0	1
400	MINING AND ROCK QUARRYING	197	19	5	44	62	1	10
480	OTHER INDUSTRIES	656	474	331	15	447	15	611
540	PETROCHEMICAL INDUSTRY	20	19	18	17	2,400	272	176
550	PETROLEUM REFINING	0	0	0	232	53	0	0
600	PULP AND PAPER INDUSTRY	0	0	0	1	0	0	0
690	UPSTREAM OIL & GAS INDUSTRY	209	209	209	56,573	35,021	48,607	5,833
700	WOOD INDUSTRY	416	220	106	0	29	0	10
		3,836	**1,664**	**1,021**	**56,930**	**38,329**	**48,931**	**6,729**
	Non Industrial Fuel Combustion							
160	COMMERCIAL FUEL COMBUSTION	35	34	34	26	359	17	67
200	ELECTRIC POWER GENERATION	4	3	3	2	175	0	13
620	RESIDENTIAL FUEL COMBUSTION	76	59	55	21	416	33	187
630	RESIDENTIAL FUELWOOD COMBUSTION	492	492	468	7	44	2,356	3,829
		606	**589**	**559**	**56**	**994**	**2,407**	**4,096**
	Transportation							
40	AIR TRANSPORTATION	21	11	8	36	618	32	570
270	HEAVY-DUTY DIESEL VEHICLES	539	539	497	271	7,084	941	4,376
280	HEAVY-DUTY GASOLINE TRUCKS	14	14	11	14	443	281	3,932
330	LIGHT-DUTY DIESEL TRUCKS	34	34	32	20	163	78	136
340	LIGHT-DUTY DIESEL VEHICLES	3	3	3	2	14	6	12
350	LIGHT-DUTY GASOLINE TRUCKS	55	54	44	55	2,431	3,335	33,341
360	LIGHT-DUTY GASOLINE VEHICLES	52	50	35	77	3,537	5,078	49,554
380	MARINE TRANSPORTATION	5	4	4	1	1	153	500
410	MOTORCYCLES	0	0	0	0	7	20	138
450	OFF-ROAD USE OF DIESEL	378	378	347	267	3,723	402	1,171
460	OFF-ROAD USE OF GASOLINE	32	26	22	11	370	844	13,916
610	RAIL TRANSPORTATION	22	22	21	52	926	43	178
670	TIRE WEAR	69	68	22	0	0	0	0
		1,225	**1,204**	**1,046**	**804**	**19,317**	**11,214**	**107,824**
	Incineration							
180	CREMATION	0	0	0	0	0	0	0
290	INDUSTRIAL & COMMERCIAL INCINERATION	3	2	2	1	2	0	2
710	WOOD WASTE INCINERATION	0	0	0	1	0	64	0
		3	**2**	**2**	**2**	**2**	**64**	**2**
	Miscellaneous							
130	CIGARETTE SMOKING	4	4	4	0	0	0	18
190	DRY CLEANING	0	0	0	0	0	46	0
230	FUEL MARKETING	0	0	0	0	0	633	0
250	GENERAL SOLVENT USE	0	0	0	0	0	1,611	0

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Miscellaneous (cont.)							
385	MEAT COOKING	7	7	7	0	0	0	0
530	PESTICIDES AND FERTILIZER APPLICATION	316	155	44	0	0	0	0
580	PRINTING	0	0	0	0	0	137	0
650	STRUCTURAL FIRES	31	30	28	0	0	30	62
660	SURFACE COATINGS	0	0	0	0	0	636	0
		358	**197**	**83**	**0**	**0**	**3,093**	**80**
	Open Sources							
20	AGRICULTURAL OPERATIONS	67,434	32,735	674	0	0	0	0
30	AGRICULTURE	13,108	7,973	1,251	0	0	0	0
170	CONSTRUCTION	59,671	13,128	266	0	0	0	0
320	LANDFILL SITES	22	2	0	0	0	13	0
390	MINE TAILINGS	184	15	4	0	0	0	0
520	PAVED ROADS	18,517	3,429	853	0	0	0	0
680	UNPAVED ROADS	123,556	36,074	5,289	0	0	0	0
		282,491	**93,354**	**8,338**	**0**	**0**	**13**	**0**
	TOTAL	**288,519**	**97,011**	**11,049**	**57,792**	**58,643**	**65,723**	**118,731**

3 SOUTH WOOD BUFFALO

SIC REPORT NAME CODE	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Industrial Sources							
80	ASPHALT PAVING INDUSTRY	43	6	2	0	0	0	0
90	BAKERIES	0	0	0	0	0	1	0
110	CEMENT AND CONCRETE INDUSTRY	1	1	0	0	0	0	0
120	CHEMICAL INDUSTRY	1	1	1	0	21	0	4
140	CLAY PRODUCTS INDUSTRY	1	0	0	0	0	0	0
150	COAL INDUSTRY	367	273	212	33	18	13	0
210	FERROUS FOUNDRIES	0	0	0	0	0	0	3
260	GRAIN INDUSTRIES	7	1	0	0	0	0	0
300	IRON AND STEEL PRODUCTION	0	0	0	0	0	0	0
400	MINING AND ROCK QUARRYING	152	15	4	34	48	1	8
470	OIL SANDS	3,937	1,787	1,407	160,948	16,542	81	1,447
480	OTHER INDUSTRIES	246	156	95	2	41	3	71
600	PULP AND PAPER INDUSTRY	0	0	0	0	0	0	0
690	UPSTREAM OIL & GAS INDUSTRY	11	10	9	6,407	4,106	36,478	709
700	WOOD INDUSTRY	491	265	177	0	62	0	7,135
		5,259	**2,516**	**1,908**	**167,425**	**20,837**	**36,578**	**9,376**
	Non Industrial Fuel Combustion							
160	COMMERCIAL FUEL COMBUSTION	6	6	5	4	58	3	11
200	ELECTRIC POWER GENERATION	1	1	1	1	42	0	3
620	RESIDENTIAL FUEL COMBUSTION	14	11	10	4	76	6	34
630	RESIDENTIAL FUELWOOD COMBUSTION	90	90	85	1	8	429	697
		110	**107**	**101**	**10**	**184**	**438**	**745**
	Transportation							
40	AIR TRANSPORTATION	5	3	2	9	138	55	470
270	HEAVY-DUTY DIESEL VEHICLES	0	0	0	0	6	1	3
280	HEAVY-DUTY GASOLINE TRUCKS	0	0	0	0	1	1	12
330	LIGHT-DUTY DIESEL TRUCKS	0	0	0	0	1	0	0
340	LIGHT-DUTY DIESEL VEHICLES	0	0	0	0	0	0	0
350	LIGHT-DUTY GASOLINE TRUCKS	0	0	0	0	8	10	105
360	LIGHT-DUTY GASOLINE VEHICLES	0	0	0	0	10	14	136
380	MARINE TRANSPORTATION	1	1	1	0	0	36	118
410	MOTORCYCLES	0	0	0	0	0	0	0
450	OFF-ROAD USE OF DIESEL	80	80	73	56	787	85	247
460	OFF-ROAD USE OF GASOLINE	7	6	5	2	78	178	2,941
610	RAIL TRANSPORTATION	8	8	7	19	335	16	64
670	TIRE WEAR	0	0	0	0	0	0	0
		102	**99**	**89**	**87**	**1,363**	**397**	**4,098**
	Incineration							
180	CREMATION	0	0	0	0	0	0	0
710	WOOD WASTE INCINERATION	0	0	0	0	0	17	0
		0	**0**	**0**	**0**	**0**	**17**	**0**
	Miscellaneous							
130	CIGARETTE SMOKING	1	1	1	0	0	0	3
190	DRY CLEANING	0	0	0	0	0	9	0
230	FUEL MARKETING	0	0	0	0	0	102	0
250	GENERAL SOLVENT USE	0	0	0	0	0	230	0

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Miscellaneous (cont.)							
385	MEAT COOKING	1	1	1	0	0	0	0
530	PESTICIDES AND FERTILIZER APPLICATION	1	1	0	0	0	0	0
580	PRINTING	0	0	0	0	0	11	0
650	STRUCTURAL FIRES	5	4	4	0	0	4	9
660	SURFACE COATINGS	0	0	0	0	0	85	0
		8	**7**	**6**	**0**	**0**	**441**	**13**
	Open Sources							
20	AGRICULTURAL OPERATIONS	292	142	3	0	0	0	0
30	AGRICULTURE	57	35	5	0	0	0	0
170	CONSTRUCTION	12,610	2,774	56	0	0	0	0
320	LANDFILL SITES	5	0	0	0	0	3	0
390	MINE TAILINGS	142	11	3	0	0	0	0
520	PAVED ROADS	467	104	21	0	0	0	0
570	PRESCRIBED BURNING	963	822	576	3	127	355	5,877
680	UNPAVED ROADS	16,086	4,648	689	0	0	0	0
220	FOREST FIRES	3,320	2,822	2,324	2	871	3,750	27,345
		33,943	**11,359**	**3,677**	**5**	**998**	**4,108**	**33,222**
	TOTAL	**39,422**	**14,088**	**5,782**	**167,527**	**23,382**	**41,979**	**47,454**

4 EDMONTON

1995 CAC EMISSIONS IN TONNES

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Industrial Sources							
50	ALUMINUM INDUSTRY	0	0	0	2,419	227	0	0
80	ASPHALT PAVING INDUSTRY	959	144	48	0	0	0	0
90	BAKERIES	0	0	0	0	0	120	0
110	CEMENT AND CONCRETE INDUSTRY	844	208	52	4	2,555	12	94
120	CHEMICAL INDUSTRY	144	144	143	1,854	9,742	123	394
140	CLAY PRODUCTS INDUSTRY	120	8	0	0	0	0	0
150	COAL INDUSTRY	701	520	405	63	34	24	0
210	FERROUS FOUNDRIES	28	27	25	0	1	0	268
260	GRAIN INDUSTRIES	2,134	409	56	0	0	0	0
300	IRON AND STEEL PRODUCTION	3	2	2	31	35	1	6
400	MINING AND ROCK QUARRYING	291	29	7	66	91	2	15
480	OTHER INDUSTRIES	2,241	1,809	1,417	84	3,149	82	1,528
540	PETROCHEMICAL INDUSTRY	169	169	5	254	3,554	7,715	330
550	PETROLEUM REFINING	821	821	821	8,416	3,776	746	1,012
600	PULP AND PAPER INDUSTRY	0	0	0	4	1	0	0
690	UPSTREAM OIL & GAS INDUSTRY	99	99	99	16,604	18,312	70,239	3,078
700	WOOD INDUSTRY	1,596	843	453	0	532	11	1,156
		10,148	**5,231**	**3,534**	**29,799**	**42,009**	**79,075**	**7,883**
	Non Industrial Fuel Combustion							
160	COMMERCIAL FUEL COMBUSTION	196	192	189	144	2,012	96	375
200	ELECTRIC POWER GENERATION	6,185	6,184	6,184	66,791	57,728	763	4,924
620	RESIDENTIAL FUEL COMBUSTION	409	320	295	112	2,253	181	1,015
630	RESIDENTIAL FUELWOOD COMBUSTION	2,664	2,664	2,531	38	236	12,755	20,729
		9,454	**9,360**	**9,199**	**67,085**	**62,230**	**13,796**	**27,042**
	Transportation							
40	AIR TRANSPORTATION	29	16	11	68	758	579	2,613
270	HEAVY-DUTY DIESEL VEHICLES	1,540	1,540	1,420	773	20,251	2,690	12,510
280	HEAVY-DUTY GASOLINE TRUCKS	39	38	30	39	1,227	779	10,888
330	LIGHT-DUTY DIESEL TRUCKS	95	95	88	55	450	216	374
340	LIGHT-DUTY DIESEL VEHICLES	9	9	8	4	40	16	33
350	LIGHT-DUTY GASOLINE TRUCKS	154	149	123	153	6,734	9,239	92,376
360	LIGHT-DUTY GASOLINE VEHICLES	145	140	98	214	9,855	14,148	138,068
380	MARINE TRANSPORTATION	33	26	22	3	6	952	3,109
410	MOTORCYCLES	1	1	0	1	21	57	388
450	OFF-ROAD USE OF DIESEL	1,777	1,777	1,635	1,255	17,521	1,893	5,510
460	OFF-ROAD USE OF GASOLINE	152	124	106	50	1,741	3,972	65,490
610	RAIL TRANSPORTATION	58	58	54	135	2,409	113	463
670	TIRE WEAR	192	190	61	0	0	0	0
		4,222	**4,163**	**3,656**	**2,751**	**61,014**	**34,653**	
	Incineration							
180	CREMATION	0	0	0	0	1	0	0
710	WOOD WASTE INCINERATION	0	0	0	1	0	147	0
		0	**0**	**0**	**1**	**1**	**147**	**0**
	Miscellaneous							
130	CIGARETTE SMOKING	20	20	20	0	0	0	94
190	DRY CLEANING	0	0	0	0	0	270	0
230	FUEL MARKETING	0	0	0	0	0	3,589	0
250	GENERAL SOLVENT USE	0	0	0	0	0	9,773	0
385	MEAT COOKING	39	39	39	0	0	0	0
530	PESTICIDES AND FERTILIZER APPLICATION	421	206	59	0	0	0	0
580	PRINTING	0	0	0	0	0	1,010	0
650	STRUCTURAL FIRES	253	250	228	0	0	245	506
660	SURFACE COATINGS	0	0	0	0	0	3,934	0
		733	**515**	**345**	**0**	**0**	**18,822**	**600**

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Open Sources							
20	AGRICULTURAL OPERATIONS	89,705	43,546	897	0	0	0	0
30	AGRICULTURE	17,437	10,606	1,665	0	0	0	0
170	CONSTRUCTION	280,814	61,779	1,250	0	0	0	0
320	LANDFILL SITES	210	17	4	0	0	126	0
390	MINE TAILINGS	271	22	5	0	0	0	0
520	PAVED ROADS	48,823	8,982	2,250	0	0	0	0
680	UNPAVED ROADS	153,094	44,696	6,554	0	0	0	0
		590,354	**169,648**	**12,626**	**0**	**0**	**126**	**0**
	TOTAL	**614,911**	**188,918**	**29,361**	**99,636**	**165,253**	**146,619**	**367,347**

5 CALGARY

1995 CAC EMISSIONS IN TONNES

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Industrial Sources							
80	ASPHALT PAVING INDUSTRY	922	138	46	0	0	0	0
90	BAKERIES	0	0	0	0	0	116	0
110	CEMENT AND CONCRETE INDUSTRY	863	216	60	3,090	5,083	24	183
120	CHEMICAL INDUSTRY	665	639	184	10	3,117	1,887	3,464
140	CLAY PRODUCTS INDUSTRY	116	8	0	0	0	0	0
150	COAL INDUSTRY	1,653	1,226	955	148	80	57	0
210	FERROUS FOUNDRIES	27	26	24	0	0	0	259
260	GRAIN INDUSTRIES	745	143	20	0	0	0	0
300	IRON AND STEEL PRODUCTION	3	2	2	30	34	1	6
400	MINING AND ROCK QUARRYING	686	67	17	155	215	5	35
480	OTHER INDUSTRIES	1,966	1,440	1,027	80	2,781	66	1,141
550	PETROLEUM REFINING	0	0	0	55	0	7	0
600	PULP AND PAPER INDUSTRY	0	0	0	3	1	0	0
690	UPSTREAM OIL & GAS INDUSTRY	103	103	103	52,079	18,910	164,244	3,643
700	WOOD INDUSTRY	855	469	272	0	80	0	9,256
		8,602	**4,479**	**2,710**	**55,651**	**30,302**	**266,402**	**17,987**
	Non Industrial Fuel Combustion							
160	COMMERCIAL FUEL COMBUSTION	176	173	170	130	1,813	87	338
200	ELECTRIC POWER GENERATION	32	31	31	20	1,567	4	114
620	RESIDENTIAL FUEL COMBUSTION	373	292	270	102	2,056	165	926
630	RESIDENTIAL FUELWOOD COMBUSTION	2,431	2,431	2,309	35	216	11,639	18,915
		3,012	**2,927**	**2,779**	**287**	**5,652**	**11,895**	**20,292**
	Transportation							
40	AIR TRANSPORTATION	38	21	15	100	1,045	961	3,885
270	HEAVY-DUTY DIESEL VEHICLES	698	698	643	350	9,175	1,219	5,668
280	HEAVY-DUTY GASOLINE TRUCKS	18	17	14	18	563	357	4,992
330	LIGHT-DUTY DIESEL TRUCKS	44	44	40	25	207	99	172
340	LIGHT-DUTY DIESEL VEHICLES	4	4	4	2	18	7	15
350	LIGHT-DUTY GASOLINE TRUCKS	71	68	56	70	3,093	4,244	42,431
360	LIGHT-DUTY GASOLINE VEHICLES	66	64	45	98	4,515	6,483	63,264
380	MARINE TRANSPORTATION	35	28	23	3	7	1,021	3,336
410	MOTORCYCLES	0	0	0	0	10	26	179
450	OFF-ROAD USE OF DIESEL	1,710	1,710	1,573	1,208	16,858	1,821	5,302
460	OFF-ROAD USE OF GASOLINE	146	120	102	48	1,675	3,822	63,012
610	RAIL TRANSPORTATION	39	39	36	90	1,615	76	310
670	TIRE WEAR	88	87	28	0	0	0	0
		2,956	**2,900**	**2,580**	**2,014**	**38,781**	**20,136**	**192,564**
	Incineration							
180	CREMATION	0	0	0	0	1	0	0
710	WOOD WASTE INCINERATION	0	0	0	1	0	92	0
		0	**0**	**0**	**1**	**1**	**92**	**0**
	Miscellaneous							
130	CIGARETTE SMOKING	18	18	18	0	0	0	86
190	DRY CLEANING	0	0	0	0	0	279	0
230	FUEL MARKETING	0	0	0	0	0	3,237	0
250	GENERAL SOLVENT USE	0	0	0	0	0	9,116	0
385	MEAT COOKING	35	35	35	0	0	0	0
530	PESTICIDES AND FERTILIZER APPLICATION	147	72	21	0	0	0	0
580	PRINTING	0	0	0	0	0	976	0
650	STRUCTURAL FIRES	152	151	137	0	0	148	304
660	SURFACE COATINGS	0	0	0	0	0	3,680	0
		353	**276**	**211**	**0**	**0**	**17,436**	**390**

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Open Sources							
20	AGRICULTURAL OPERATIONS	31,301	15,195	313	0	0	0	0
30	AGRICULTURE	6,084	3,701	581	0	0	0	0
170	CONSTRUCTION	270,186	59,441	1,203	0	0	0	0
320	LANDFILL SITES	192	15	4	0	0	116	0
390	MINE TAILINGS	640	51	13	0	0	0	0
520	PAVED ROADS	28,515	5,384	1,310	0	0	0	0
680	UNPAVED ROADS	21,950	6,395	940	0	0	0	0
		358,869	**90,182**	**4,363**	**0**	**0**	**116**	**0**
	TOTAL	**373,792**	**100,764**	**12,644**	**57,952**	**74,736**	**216,077**	**231,233**

6 SOUTH ALBERTA

1995 CAC EMISSIONS IN TONNES

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Industrial Sources							
80	ASPHALT PAVING INDUSTRY	258	39	13	0	0	0	0
90	BAKERIES	0	0	0	0	0	25	0
110	CEMENT AND CONCRETE INDUSTRY	26	13	4	0	0	0	0
120	CHEMICAL INDUSTRY	75	31	27	11	2,076	5	68
140	CLAY PRODUCTS INDUSTRY	25	2	0	0	0	0	0
150	COAL INDUSTRY	348	258	201	31	17	12	0
210	FERROUS FOUNDRIES	6	6	5	0	0	0	55
260	GRAIN INDUSTRIES	2,692	516	71	0	0	0	0
300	IRON AND STEEL PRODUCTION	1	0	0	6	7	0	1
400	MINING AND ROCK QUARRYING	144	14	4	33	45	1	7
480	OTHER INDUSTRIES	662	518	173	18	1,090	13	720
540	PETROCHEMICAL INDUSTRY	0	0	0	0	1,590	541	792
600	PULP AND PAPER INDUSTRY	0	0	0	0	0	0	0
690	UPSTREAM OIL & GAS INDUSTRY	276	276	276	31,037	37,578	36,477	6,207
700	WOOD INDUSTRY	2,812	1,515	984	0	330	0	24,973
		7,323	**3,189**	**1,759**	**31,137**	**42,734**	**37,073**	**32,824**
	Non Industrial Fuel Combustion							
160	COMMERCIAL FUEL COMBUSTION	46	45	44	34	474	23	88
200	ELECTRIC POWER GENERATION	16	16	16	3	1,800	6	158
620	RESIDENTIAL FUEL COMBUSTION	108	84	78	30	593	48	267
630	RESIDENTIAL FUELWOOD COMBUSTION	701	701	666	10	62	3,357	5,455
		871	**846**	**804**	**77**	**2,929**	**3,433**	**5,969**
	Transportation							
40	AIR TRANSPORTATION	35	19	14	61	1,018	141	979
270	HEAVY-DUTY DIESEL VEHICLES	827	827	762	415	10,872	1,444	6,716
280	HEAVY-DUTY GASOLINE TRUCKS	22	21	17	22	680	432	6,035
330	LIGHT-DUTY DIESEL TRUCKS	53	53	49	31	250	120	208
340	LIGHT-DUTY DIESEL VEHICLES	5	5	4	2	22	9	18
350	LIGHT-DUTY GASOLINE TRUCKS	85	82	68	85	3,729	5,116	51,152
360	LIGHT-DUTY GASOLINE VEHICLES	80	77	54	118	5,428	7,793	76,045
380	MARINE TRANSPORTATION	8	6	5	1	2	232	758
410	MOTORCYCLES	0	0	0	0	11	31	210
450	OFF-ROAD USE OF DIESEL	478	478	440	338	4,711	509	1,482
460	OFF-ROAD USE OF GASOLINE	41	33	28	14	468	1,068	17,610
610	RAIL TRANSPORTATION	89	89	82	205	3,675	173	706
670	TIRE WEAR	106	105	34	0	0	0	0
		1,827	**1,796**	**1,558**	**1,291**	**30,866**	**17,067**	**161,920**
	Incineration							
180	CREMATION	0	0	0	0	0	0	0
290	INDUSTRIAL & COMMERCIAL INCINERATION	5	4	4	5	11	3	1
710	WOOD WASTE INCINERATION	0	0	0	0	0	31	0
		5	**4**	**4**	**6**	**11**	**34**	**1**
	Miscellaneous							
130	CIGARETTE SMOKING	5	5	5	0	0	0	26
190	DRY CLEANING	0	0	0	0	0	61	0
230	FUEL MARKETING	0	0	0	0	0	833	0
250	GENERAL SOLVENT USE	0	0	0	0	0	2,316	0
385	MEAT COOKING	10	10	10	0	0	0	0

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Miscellaneous (cont.)							
530	PESTICIDES AND FERTILIZER APPLICATION	531	260	74	0	0	0	0
580	PRINTING	0	0	0	0	0	207	0
650	STRUCTURAL FIRES	56	55	50	0	0	54	112
660	SURFACE COATINGS	0	0	0	0	0	911	0
		603	**331**	**140**	**0**	**0**	**4,383**	**137**
	Open Sources							
20	AGRICULTURAL OPERATIONS	113,196	54,950	1,132	0	0	0	0
30	AGRICULTURE	22,003	13,384	2,101	0	0	0	0
170	CONSTRUCTION	75,510	16,612	336	0	0	0	0
320	LANDFILL SITES	31	2	1	0	0	19	0
390	MINE TAILINGS	135	11	3	0	0	0	0
520	PAVED ROADS	24,662	4,434	1,140	0	0	0	0
680	UNPAVED ROADS	280,550	81,392	12,010	0	0	0	0
		516,086	**170,785**	**16,722**	**0**	**0**	**19**	**0**
	TOTAL	**526,715**	**176,951**	**20,986**	**32,510**	**76,540**	**62,008**	**200,851**

7 DRUMHELLER

1995 CAC EMISSIONS IN TONNES

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Industrial Sources							
80	ASPHALT PAVING INDUSTRY	59	9	3	0	0	0	0
90	BAKERIES	0	0	0	0	0	3	0
110	CEMENT AND CONCRETE INDUSTRY	3	2	0	0	0	0	0
120	CHEMICAL INDUSTRY	3	3	3	0	48	1	8
140	CLAY PRODUCTS INDUSTRY	3	0	0	0	0	0	0
150	COAL INDUSTRY	164	121	95	15	8	6	0
210	FERROUS FOUNDRIES	1	1	1	0	0	0	7
260	GRAIN INDUSTRIES	1,394	267	37	0	0	0	0
300	IRON AND STEEL PRODUCTION	0	0	0	1	1	0	0
400	MINING AND ROCK QUARRYING	68	7	2	15	21	0	3
480	OTHER INDUSTRIES	95	56	32	3	76	2	30
600	PULP AND PAPER INDUSTRY	0	0	0	0	0	0	0
690	UPSTREAM OIL & GAS INDUSTRY	27	27	27	16,867	29,167	17,729	4,155
700	WOOD INDUSTRY	37	21	7	0	0	0	0
		1,853	**514**	**206**	**16,901**	**29,321**	**17,741**	**4,203**
	Non Industrial Fuel Combustion							
160	COMMERCIAL FUEL COMBUSTION	9	9	9	7	94	5	18
200	ELECTRIC POWER GENERATION	2,493	1,803	1,630	60,435	22,430	277	1,740
620	RESIDENTIAL FUEL COMBUSTION	27	21	19	7	147	12	66
630	RESIDENTIAL FUELWOOD COMBUSTION	174	174	165	2	15	832	1,352
		2,702	**2,006**	**1,823**	**60,452**	**22,686**	**1,125**	**3,176**
	Transportation							
40	AIR TRANSPORTATION	22	12	9	40	721	14	89
270	HEAVY-DUTY DIESEL VEHICLES	221	221	203	111	2,900	385	1,792
280	HEAVY-DUTY GASOLINE TRUCKS	6	6	5	6	202	128	1,795
330	LIGHT-DUTY DIESEL TRUCKS	16	16	15	9	75	36	63
340	LIGHT-DUTY DIESEL VEHICLES	1	1	1	1	6	3	5
350	LIGHT-DUTY GASOLINE TRUCKS	25	25	20	25	1,110	1,523	15,222
360	LIGHT-DUTY GASOLINE VEHICLES	23	23	16	34	1,587	2,278	22,229
380	MARINE TRANSPORTATION	2	2	1	0	0	64	208
410	MOTORCYCLES	0	0	0	0	3	9	59
450	OFF-ROAD USE OF DIESEL	110	110	101	77	1,081	117	340
460	OFF-ROAD USE OF GASOLINE	9	8	7	3	107	245	4,041
610	RAIL TRANSPORTATION	42	42	39	97	1,744	82	335
670	TIRE WEAR	31	31	10	0	0	0	0
		509	**495**	**427**	**405**	**9,537**	**4,883**	**46,179**
	Incineration							
180	CREMATION	0	0	0	0	0	0	0
710	WOOD WASTE INCINERATION	0	0	0	0	0	12	0
		0	**0**	**0**	**0**	**0**	**12**	**0**
	Miscellaneous							
130	CIGARETTE SMOKING	1	1	1	0	0	0	6
190	DRY CLEANING	0	0	0	0	0	12	0
230	FUEL MARKETING	0	0	0	0	0	167	0
250	GENERAL SOLVENT USE	0	0	0	0	0	441	0
385	MEAT COOKING	2	2	2	0	0	0	0
530	PESTICIDES AND FERTILIZER APPLICATION	275	135	38	0	0	0	0
580	PRINTING	0	0	0	0	0	26	0
650	STRUCTURAL FIRES	13	12	11	0	0	12	25
660	SURFACE COATINGS	0	0	0	0	0	158	0
		291	**151**	**53**	**0**	**0**	**816**	**32**

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Open Sources							
20	AGRICULTURAL OPERATIONS	58,593	28,443	586	0	0	0	0
30	AGRICULTURE	11,389	6,928	1,087	0	0	0	0
170	CONSTRUCTION	17,326	3,812	77	0	0	0	0
320	LANDFILL SITES	10	1	0	0	0	6	0
390	MINE TAILINGS	63	5	1	0	0	0	0
520	PAVED ROADS	14,986	3,055	681	0	0	0	0
680	UNPAVED ROADS	359,566	104,217	15,393	0	0	0	0
		461,933	**146,461**	**17,826**	**0**	**0**	**6**	**0**
	TOTAL	**467,288**	**149,627**	**20,335**	**77,758**	**61,545**	**24,582**	**53,590**

8 WAINWRIGHT/LLOYDMINSTER

1995 CAC EMISSIONS IN TONNES

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Industrial Sources							
80	ASPHALT PAVING INDUSTRY	57	9	3	0	0	0	0
90	BAKERIES	0	0	0	0	0	3	0
110	CEMENT AND CONCRETE INDUSTRY	3	2	0	0	0	0	0
120	CHEMICAL INDUSTRY	6	6	6	0	73	2	14
140	CLAY PRODUCTS INDUSTRY	3	0	0	0	0	0	0
150	COAL INDUSTRY	165	123	96	15	8	6	0
210	FERROUS FOUNDRIES	1	1	1	0	0	0	7
260	GRAIN INDUSTRIES	930	178	24	0	0	0	0
300	IRON AND STEEL PRODUCTION	0	0	0	1	1	0	0
400	MINING AND ROCK QUARRYING	69	7	2	15	21	0	4
480	OTHER INDUSTRIES	120	79	50	3	77	2	46
550	PETROLEUM REFINING	9	9	9	38	95	2	24
600	PULP AND PAPER INDUSTRY	0	0	0	0	0	0	0
690	UPSTREAM OIL & GAS INDUSTRY	18	12	10	3,916	13,120	17,030	2,214
700	WOOD INDUSTRY	34	20	6	0	0	0	0
		1,416	**445**	**208**	**3,988**	**13,395**	**17,045**	**2,308**
	Non Industrial Fuel Combustion							
160	COMMERCIAL FUEL COMBUSTION	11	11	11	8	118	6	22
200	ELECTRIC POWER GENERATION	2	2	2	1	77	0	6
620	RESIDENTIAL FUEL COMBUSTION	28	22	20	8	155	12	70
630	RESIDENTIAL FUELWOOD COMBUSTION	184	184	175	3	16	880	1,429
		225	**219**	**207**	**20**	**367**	**898**	**1,527**
	Transportation							
40	AIR TRANSPORTATION	11	6	4	20	339	25	291
270	HEAVY-DUTY DIESEL VEHICLES	370	370	342	186	4,872	647	3,009
280	HEAVY-DUTY GASOLINE TRUCKS	10	9	8	10	303	192	2,690
330	LIGHT-DUTY DIESEL TRUCKS	23	23	22	14	111	53	93
340	LIGHT-DUTY DIESEL VEHICLES	2	2	2	1	10	4	8
350	LIGHT-DUTY GASOLINE TRUCKS	38	37	30	38	1,662	2,280	22,792
360	LIGHT-DUTY GASOLINE VEHICLES	36	34	24	52	2,421	3,476	33,921
380	MARINE TRANSPORTATION	2	2	2	0	0	67	218
410	MOTORCYCLES	0	0	0	0	5	14	93
450	OFF-ROAD USE OF DIESEL	106	106	98	75	1,046	113	329
460	OFF-ROAD USE OF GASOLINE	9	7	6	3	104	237	3,910
610	RAIL TRANSPORTATION	39	39	36	90	1,609	76	309
670	TIRE WEAR	47	47	15	0	0	0	0
		694	**684**	**588**	**489**	**12,482**	**7,183**	**67,663**
	Incineration							
180	CREMATION	0	0	0	0	0	0	0
710	WOOD WASTE INCINERATION	0	0	0	0	0	11	0
		0	**0**	**0**	**0**	**0**	**11**	**0**
	Miscellaneous							
130	CIGARETTE SMOKING	1	1	1	0	0	0	6
190	DRY CLEANING	0	0	0	0	0	12	0
230	FUEL MARKETING	0	0	0	0	0	209	0
250	GENERAL SOLVENT USE	0	0	0	0	0	475	0
385	MEAT COOKING	3	3	3	0	0	0	0
530	PESTICIDES AND FERTILIZER APPLICATION	183	90	26	0	0	0	0
580	PRINTING	0	0	0	0	0	26	0
650	STRUCTURAL FIRES	15	15	14	0	0	15	31
660	SURFACE COATINGS	0	0	0	0	0	174	0
		203	**109**	**43**	**0**	**0**	**910**	**37**

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Open Sources							
20	AGRICULTURAL OPERATIONS	39,082	18,972	391	0	0	0	0
30	AGRICULTURE	7,597	4,621	725	0	0	0	0
170	CONSTRUCTION	16,764	3,688	75	0	0	0	0
320	LANDFILL SITES	10	1	0	0	0	6	0
390	MINE TAILINGS	64	5	1	0	0	0	0
520	PAVED ROADS	13,701	2,616	628	0	0	0	0
680	UNPAVED ROADS	286,175	82,808	12,251	0	0	0	0
		363,392	**112,711**	**14,072**	**0**	**0**	**6**	**0**
	TOTAL	**365,930**	**114,168**	**15,118**	**4,497**	**26,244**	**26,053**	**71,534**

9 GRANDE PRAIRIE/PEACE RIVER

1995 CAC EMISSIONS IN TONNES

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Industrial Sources							
80	ASPHALT PAVING INDUSTRY	164	25	8	0	0	0	0
90	BAKERIES	0	0	0	0	0	15	0
110	CEMENT AND CONCRETE INDUSTRY	16	8	2	0	0	0	0
120	CHEMICAL INDUSTRY	15	15	15	11	240	3	41
140	CLAY PRODUCTS INDUSTRY	15	1	0	0	0	0	0
150	COAL INDUSTRY	873	557	390	568	230	137	0
210	FERROUS FOUNDRIES	3	3	3	0	0	0	33
260	GRAIN INDUSTRIES	1,248	239	33	0	0	0	0
300	IRON AND STEEL PRODUCTION	0	0	0	4	4	0	1
400	MINING AND ROCK QUARRYING	171	17	4	39	54	1	9
480	OTHER INDUSTRIES	2,618	2,283	1,889	15	532	70	1,684
600	PULP AND PAPER INDUSTRY	1,321	1,275	1,240	1,857	2,330	21	400
690	UPSTREAM OIL & GAS INDUSTRY	164	162	162	63,294	43,679	42,914	6,019
700	WOOD INDUSTRY	12,707	6,851	4,567	1	2,836	0	149,711
		19,315	**11,437**	**8,314**	**65,789**	**49,905**	**43,162**	**157,897**
	Non Industrial Fuel Combustion							
160	COMMERCIAL FUEL COMBUSTION	26	25	25	19	266	13	50
200	ELECTRIC POWER GENERATION	872	872	849	3,200	1,726	18	590
620	RESIDENTIAL FUEL COMBUSTION	56	44	40	15	309	25	139
630	RESIDENTIAL FUELWOOD COMBUSTION	365	365	347	5	32	1,746	2,838
		1,318	**1,306**	**1,261**	**3,239**	**2,333**	**1,802**	**3,617**
	Transportation							
40	AIR TRANSPORTATION	41	23	16	73	1,262	169	1,093
270	HEAVY-DUTY DIESEL VEHICLES	14	14	13	7	184	24	113
280	HEAVY-DUTY GASOLINE TRUCKS	1	1	1	1	45	29	403
330	LIGHT-DUTY DIESEL TRUCKS	4	4	4	2	18	9	15
340	LIGHT-DUTY DIESEL VEHICLES	0	0	0	0	1	0	1
350	LIGHT-DUTY GASOLINE TRUCKS	6	6	5	6	249	342	3,417
360	LIGHT-DUTY GASOLINE VEHICLES	5	4	3	7	314	451	4,405
380	MARINE TRANSPORTATION	5	4	4	1	1	159	518
410	MOTORCYCLES	0	0	0	0	1	2	10
450	OFF-ROAD USE OF DIESEL	304	304	280	215	2,999	324	943
460	OFF-ROAD USE OF GASOLINE	26	21	18	9	298	680	11,209
610	RAIL TRANSPORTATION	74	74	68	170	3,040	143	584
670	TIRE WEAR	6	6	2	0	0	0	0
		486	**462**	**413**	**490**	**8,412**	**2,331**	**22,712**
	Incineration							
180	CREMATION	0	0	0	0	0	0	0
290	INDUSTRIAL & COMMERCIAL INCINERATION	1	0	0	0	0	0	0
710	WOOD WASTE INCINERATION	0	0	0	3	0	321	0
		1	**0**	**0**	**3**	**0**	**321**	**0**
	Miscellaneous							
130	CIGARETTE SMOKING	3	3	3	0	0	0	14
190	DRY CLEANING	0	0	0	0	0	32	0
230	FUEL MARKETING	0	0	0	0	0	472	0
250	GENERAL SOLVENT USE	0	0	0	0	0	1,281	0
385	MEAT COOKING	5	5	5	0	0	0	0
530	PESTICIDES AND FERTILIZER APPLICATION	246	121	34	0	0	0	0
580	PRINTING	0	0	0	0	0	124	0
650	STRUCTURAL FIRES	25	25	22	0	0	24	50
660	SURFACE COATINGS	0	0	0	0	0	512	0
		279	**154**	**65**	**0**	**0**	**2,446**	**64**

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Open Sources							
20	AGRICULTURAL OPERATIONS	52,482	25,477	525	0	0	0	0
30	AGRICULTURE	10,201	6,205	974	0	0	0	0
170	CONSTRUCTION	48,062	10,574	214	0	0	0	0
320	LANDFILL SITES	20	2	0	0	0	12	0
390	MINE TAILINGS	160	13	3	0	0	0	0
520	PAVED ROADS	16,518	3,606	742	0	0	0	0
570	PRESCRIBED BURNING	333	284	199	1	44	123	2,031
680	UNPAVED ROADS	228,838	65,613	9,798	0	0	0	0
220	FOREST FIRES	1,148	975	803	1	301	1,296	9,451
		357,761	**112,749**	**13,259**	**2**	**345**	**1,431**	**11,482**
	TOTAL	**379,160**	**126,108**	**23,312**	**69,523**	**60,995**	**51,492**	**195,772**

10 ATHABASCA/COLD LAKE

1995 CAC EMISSIONS IN TONNES

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Industrial Sources							
80	ASPHALT PAVING INDUSTRY	108	16	5	0	0	0	0
90	BAKERIES	0	0	0	0	0	7	0
110	CEMENT AND CONCRETE INDUSTRY	7	4	1	0	0	0	0
120	CHEMICAL INDUSTRY	7	7	7	1	103	1	18
140	CLAY PRODUCTS INDUSTRY	7	0	0	0	0	0	0
150	COAL INDUSTRY	219	162	126	20	11	8	0
210	FERROUS FOUNDRIES	2	1	1	0	0	0	15
260	GRAIN INDUSTRIES	1,002	192	26	0	0	0	0
300	IRON AND STEEL PRODUCTION	0	0	0	2	2	0	0
400	MINING AND ROCK QUARRYING	91	9	2	20	28	1	5
480	OTHER INDUSTRIES	708	599	485	7	205	19	436
550	PETROLEUM REFINING	3	2	2	6,492	32	1	8
600	PULP AND PAPER INDUSTRY	584	431	379	118	1,314	13	232
690	UPSTREAM OIL & GAS INDUSTRY	175	145	134	7,350	34,580	23,491	5,816
700	WOOD INDUSTRY	3,017	1,679	1,084	0	183	0	19,978
		5,928	**3,249**	**2,253**	**14,009**	**36,459**	**23,540**	**26,508**
	Non Industrial Fuel Combustion							
160	COMMERCIAL FUEL COMBUSTION	14	14	14	10	146	7	27
200	ELECTRIC POWER GENERATION	2	2	2	1	93	0	6
620	RESIDENTIAL FUEL COMBUSTION	39	31	28	11	216	17	97
630	RESIDENTIAL FUELWOOD COMBUSTION	256	256	243	4	23	1,225	1,991
		311	**302**	**287**	**26**	**478**	**1,250**	**2,122**
	Transportation							
40	AIR TRANSPORTATION	26	14	10	48	874	17	151
270	HEAVY-DUTY DIESEL VEHICLES	9	9	8	5	118	16	73
280	HEAVY-DUTY GASOLINE TRUCKS	1	1	1	1	31	20	276
330	LIGHT-DUTY DIESEL TRUCKS	3	3	2	2	13	6	10
340	LIGHT-DUTY DIESEL VEHICLES	0	0	0	0	1	0	1
350	LIGHT-DUTY GASOLINE TRUCKS	4	4	3	4	171	234	2,343
360	LIGHT-DUTY GASOLINE VEHICLES	3	3	2	5	216	310	3,022
380	MARINE TRANSPORTATION	3	2	2	0	1	82	269
410	MOTORCYCLES	0	0	0	0	0	1	6
450	OFF-ROAD USE OF DIESEL	201	201	185	142	1,979	214	622
460	OFF-ROAD USE OF GASOLINE	17	14	12	6	197	449	7,397
610	RAIL TRANSPORTATION	86	86	80	199	3,566	167	685
670	TIRE WEAR	4	4	1	0	0	0	0
		357	**342**	**306**	**410**	**7,165**	**1,516**	**14,855**
	Incineration							
180	CREMATION	0	0	0	0	0	0	0
290	INDUSTRIAL & COMMERCIAL INCINERATION	12	10	5	1	0	0	2
710	WOOD WASTE INCINERATION	0	0	0	1	0	134	0
		12	**10**	**5**	**2**	**0**	**134**	**2**
	Miscellaneous							
130	CIGARETTE SMOKING	2	2	2	0	0	0	10
190	DRY CLEANING	0	0	0	0	0	19	0
230	FUEL MARKETING	0	0	0	0	0	255	0
250	GENERAL SOLVENT USE	0	0	0	0	0	743	0
385	MEAT COOKING	4	4	4	0	0	0	0
530	PESTICIDES AND FERTILIZER APPLICATION	198	97	28	0	0	0	0

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Miscellaneous (cont.)							
580	PRINTING	0	0	0	0	0	56	0
650	STRUCTURAL FIRES	42	42	38	0	0	41	84
660	SURFACE COATINGS	0	0	0	0	0	280	0
		245	**144**	**71**	**0**	**0**	**1,393**	**94**
	Open Sources							
20	AGRICULTURAL OPERATIONS	42,116	20,445	421	0	0	0	0
30	AGRICULTURE	8,186	4,979	782	0	0	0	0
170	CONSTRUCTION	31,717	6,978	141	0	0	0	0
320	LANDFILL SITES	9	1	0	0	0	5	0
390	MINE TAILINGS	85	7	2	0	0	0	0
520	PAVED ROADS	9,617	2,118	432	0	0	0	0
570	PRESCRIBED BURNING	6,007	5,130	3,591	16	789	2,214	36,659
680	UNPAVED ROADS	263,983	76,324	11,301	0	0	0	0
220	FOREST FIRES	20,712	17,605	14,498	12	5,434	23,392	170,569
		382,431	**133,587**	**31,168**	**28**	**6,223**	**25,612**	**207,227**
	TOTAL	**389,284**	**137,634**	**34,092**	**14,476**	**50,325**	**53,445**	**250,808**

11 NORTHWEST

1995 CAC EMISSIONS IN TONNES

SIC	DESCRIPTION	TPM	PM_{10}	$PM_{2.5}$	SOx	NOx	VOC	CO
	Industrial Sources							
80	ASPHALT PAVING INDUSTRY	17	3	1	0	0	0	0
90	BAKERIES	0	0	0	0	0	2	0
110	CEMENT AND CONCRETE INDUSTRY	2	1	0	0	0	0	0
120	CHEMICAL INDUSTRY	2	2	2	0	28	0	5
140	CLAY PRODUCTS INDUSTRY	2	0	0	0	0	0	0
150	COAL INDUSTRY	39	29	22	3	2	1	0
210	FERROUS FOUNDRIES	0	0	0	0	0	0	4
260	GRAIN INDUSTRIES	120	23	3	0	0	0	0
300	IRON AND STEEL PRODUCTION	0	0	0	0	1	0	0
400	MINING AND ROCK QUARRYING	16	2	0	4	5	0	1
480	OTHER INDUSTRIES	396	349	291	2	70	11	259
600	PULP AND PAPER INDUSTRY	0	0	0	1	0	0	0
690	UPSTREAM OIL & GAS INDUSTRY	28	28	28	2,211	5,562	4,112	706
700	WOOD INDUSTRY	3,117	1,681	1,128	0	397	0	45,701
		3,739	**2,118**	**1,477**	**2,222**	**6,065**	**4,126**	**46,677**
	Non Industrial Fuel Combustion							
160	COMMERCIAL FUEL COMBUSTION	2	2	2	2	23	1	4
200	ELECTRIC POWER GENERATION	35	34	33	15	2,682	21	116
620	RESIDENTIAL FUEL COMBUSTION	7	5	5	2	36	3	16
630	RESIDENTIAL FUELWOOD COMBUSTION	43	43	41	1	4	204	332
		86	**84**	**81**	**19**	**2,744**	**229**	**469**
	Transportation							
40	AIR TRANSPORTATION	23	13	9	40	860	41	381
270	HEAVY-DUTY DIESEL VEHICLES	3	3	3	1	37	5	23
280	HEAVY-DUTY GASOLINE TRUCKS	0	0	0	0	11	7	94
330	LIGHT-DUTY DIESEL TRUCKS	1	1	1	1	4	2	4
340	LIGHT-DUTY DIESEL VEHICLES	0	0	0	0	0	0	0
350	LIGHT-DUTY GASOLINE TRUCKS	1	1	1	1	58	80	800
360	LIGHT-DUTY GASOLINE VEHICLES	1	1	1	2	73	105	1,024
380	MARINE TRANSPORTATION	1	1	0	0	0	22	71
410	MOTORCYCLES	0	0	0	0	0	0	3
450	OFF-ROAD USE OF DIESEL	32	32	29	23	316	34	99
460	OFF-ROAD USE OF GASOLINE	3	2	2	1	31	72	1,181
610	RAIL TRANSPORTATION	43	43	40	100	1,783	84	343
670	TIRE WEAR	1	1	0	0	0	0	0
		110	**99**	**87**	**169**	**3,175**	**451**	**4,023**
	Incineration							
180	CREMATION	0	0	0	0	0	0	0
710	WOOD WASTE INCINERATION	0	0	0	1	0	98	0
		0	**0**	**0**	**1**	**0**	**98**	**0**
	Miscellaneous							
130	CIGARETTE SMOKING	0	0	0	0	0	0	2
190	DRY CLEANING	0	0	0	0	0	3	0
230	FUEL MARKETING	0	0	0	0	0	40	0
250	GENERAL SOLVENT USE	0	0	0	0	0	146	0
385	MEAT COOKING	1	1	1	0	0	0	0
530	PESTICIDES AND FERTILIZER APPLICATION	24	12	3	0	0	0	0
580	PRINTING	0	0	0	0	0	15	0
650	STRUCTURAL FIRES	5	5	4	0	0	5	10
660	SURFACE COATINGS	0	0	0	0	0	57	0

SIC	DESCRIPTION	30 TPM	18 PM_{10}	9 $PM_{2.5}$	0 SOx	0 NOx	265 VOC	12 CO
	Open Sources							
20	AGRICULTURAL OPERATIONS	5,026	2,440	50	0	0	0	0
30	AGRICULTURE	977	594	93	0	0	0	0
170	CONSTRUCTION	5,065	1,114	23	0	0	0	0
320	LANDFILL SITES	2	0	0	0	0	1	0
390	MINE TAILINGS	15	1	0	0	0	0	0
520	PAVED ROADS	3,482	767	156	0	0	0	0
570	PRESCRIBED BURNING	8,453	7,219	5,054	23	1,111	3,116	51,585
680	UNPAVED ROADS	44,574	12,807	1,909	0	0	0	0
220	FOREST FIRES	29,145	24,773	20,401	17	7,646	32,917	240,017
		96,740	**49,717**	**27,686**	**40**	**8,757**	**36,034**	**291,602**
	TOTAL	**100,705**	**52,034**	**29,339**	**2,451**	**20,741**	**41,204**	**342,783**

Appendix G. Limitations to Rollback Analysis

While it can be a valuable tool, there are at least four limitations to rollback analysis.

1. Rollback analysis is a theoretical model. One of the assumptions of a simple rollback analysis is that an emissions reduction of the same magnitude can be achieved from every source, which makes it difficult to verify the model.
2. The application of rollback analysis requires knowing the highest ambient concentration of the pollutant of interest. Typically, the highest observed value is assumed to be this concentration. If it is not close to the true maximum, then the resulting emission reduction may not be sufficient.
3. It is assumed that a change in emissions will occur without changes in related parameters. For example, a change in vehicle emissions is assumed to be spatially distributed in a uniform manner. In real situations, urban areas tend to grow outwards so that emissions from transportation occur in new areas and rather than in the already-congested urban core.
4. Simple rollback is applicable to the problem of determining the effect on air quality of changes in emissions by a class of emitters only if:
    - the class under consideration is the largest emitter, or
    - it has the same spatial distribution as the average of all other emissions in the area, or
    - the standard is a short-term one that usually occurs under certain meteorological conditions such as inversion trapping.

Appendix H. Benefits of Lower Emissions of PM and Ozone

The MSG appreciated the importance of trying to quantify the benefits to human health and to the environment of reducing emissions of PM and ozone. However, methods to do so remain uncertain and the Group had a number of concerns about the methodology that is currently available. The main reservations are noted below.

Role of Chemistry in Toxic Effect (a scientific issue)

Particulate matter differs from conventional pollutants in that it is not composed of a single chemical compound. Instead, particulate matter refers to small solid or liquid particles with varying sizes, chemical composition, and other physical and biological properties that depend on the source of the particles and the changes they undergo in the atmosphere. Differences among studies examining the effect of particulate matter on the health of large human populations suggest that chemical composition of particulate matter may play a role in its toxic effect.

Value of a Statistical Life (a technical issue)

The monetized value of benefits predicted by the AQVM in some of the scenarios reaches amounts in the hundreds of billions of dollars, the bulk of which is associated with avoided premature deaths. The total value of benefits therefore depends on the value placed on a statistical life, which, in the literature, can range from as low as $40,000 to as much as seven million dollars. These predictions do not refer to dollars that would otherwise be available to the economy, but rather represent only a metric for measuring the value that society places on changes in risk of death or disease.

Reliability of Association

Linearity (the default assumption)

Concern was raised within the MSG about the assumption made from the epidemiological research that there is an association between particulate matter and human health effects at levels below 25 $\mu g/m^3$ of PM_{10}. The assumption that there is a linear relationship between ambient concentrations and human health benefits is an extrapolation from data points at concentrations above 25 $\mu g/m^3$. Given that most of the benefits accrue at levels lower than 25 $\mu g/m^3$, validation of this assumption is needed.

Correlation versus Causation

The available information shows a strong association between human health effects and ambient concentrations of particulate matter. The benefits predicted by the AQVM assume that this association is a causal relationship. The causal relationship between ambient particulate matter and health effects, however, is as yet unproven.

Geographical Extrapolation

Epidemiological studies used to create the AQVM were conducted mainly in American cities, which introduces uncertainty about variations in chemical composition of particulate matter. The question of transferability of these studies to the Alberta situation was raised in MSG discussions.

Lack of Ecological Benefits

The MSG focused most of its attention on human health effects, but it was recognized that particulate matter and ground-level ozone also affect the health of non-human species and ecosystems. These benefits have not been quantified for Alberta and were not considered by the MSG.

Not the Only Tool

Members of the MSG are aware that the Group did not consider all the tools that are available to account for benefits associated with reduced pollution (such as the "Quality-Adjusted Life Years" approach). Use of alternative evaluation tools would add to the information available through the AQVM.

Model Transparency

Many of the issues and concerns regarding the AQVM were exacerbated by the difficulty in acquiring information about the model itself.

Assumptions

The AQVM relies on several assumptions about the behaviour of emissions and their effects on health and the environment, which need to be confirmed by additional work. The following tables represent a qualitative attempt to better understand the connections between emissions reductions and health effects. They were not derived by the MSG and there was no consensus within the Group about the value of the tables. They are included here because this information is being used in the process. It is important to note that: a) the benefits noted in the tables do not represent dollars that would otherwise be available to the economy, and b) the benefits are accrued over 30 years – they are not annualized.

Table H-1. Population represented by "Selected Census Metropolitan Areas" in Tables H-2 and H-3 benefits assessments

	PM_{10}	$PM_{2.5}$	Ozone
Number of CMAs included	37	14	36
Percent of Canadian population	62%	52%	63%

Table H-2. Present Value Benefits of Achieving Alternative Reductions in Ambient Concentrations of $PM_{2.5}$, PM_{10}, and Ozone for Selected Census Metropolitan Areas (CMAs) for the Period 2005-2035 (central estimates, 1996$thousands, discount rate 5%, and base year 1996)

Pollutant/ Scenario	Total	Mortality	Chronic Bronchitis	Respiratory Hospital Admissions	Cardiac Hospital Admissions	Emergency Department Visits	Asthma Symptom Days	Restricted Activity Days	Acute Respiratory Symptoms	Child Bronchitis	Household Material Soiling
$PM_{2.5}$											
2.5	$192,576,229	$153,053,486	$25,770,766	$50,847	454,553	$20,360	$463,929	$8,076,931	$2,504,733	$232,465	$2,348,228
20	$110,445,459	$87,780,946	$14,779,974	$29,162	$31,288	$11,677	$266,078	$4,629,439	$1,436,544	$133,566	$1,346,782
30	$56,157,714	$44,619,681	$7,527,549	$14,824	$15,904	$5,936	$135,249	$2,356,124	$730,205	$67,652	$684,579
40	$17,591,344	$13,979,047	$2,356,316	$4,644	$4,983	$1,860	$42,373	$737,656	$228,768	$21,236	$214,474
PM_{10}											
5	$256,395,034	$190,122,032	$41,703,203	$72,010	$77,550	$29,182	$664,039	$11,342,283	$6,784,745	$441,081	$5,158,910
25	$196,791,847	$145,925,542	$32,009,152	$55,271	$59,522	$22,398	$509,674	$8,704,334	$5,207,539	$338,687	$3,959,651
40	$110,545,497	$81,954,001	$17,998,525	$31,041	$33,429	$12,579	$286,241	$4,891,420	$2,294,634	$189,890	$2,223,800
60	$35,149,794	$26,030,957	$5,748,526	$9,859	$10,618	$3,995	$90,918	$1,560,018	$928,948	$59,616	$706,343
80	$4,539,121	$3,368,727	$736,035	$1,276	$1,374	$517	$11,766	$199,861	$120,217	$7,937	$91,410
Ozone											
60	$10,764,816	$10,252,409	N/A	$11,138	N/A	$4,110	$79,602	$222,235	$195,327	N/A	N/A
70	$7,528,229	$7,169,883	N/A	$7,789	N/A	$2,874	$55,668	$155,417	$136,599	N/A	N/A
80	$4,412,553	$4,202,511	N/A	$4,565	N/A	$4,685	$32,629	$91,095	$80,065	N/A	N/A

Table H-3. Total Avoided Health Events for Alternative Reductions in Ambient Concentrations of $PM_{2.5}$, PM_{10}, and Ozone for Selected Census Metropolitan Areas (CMAs) for the Period 2005-2035 (central estimates)

Pollutant/ Scenario	Mortality	Chronic Bronchitis	Respiratory Hospital Admissions	Cardiac Hospital Admissions	Emergency Department Visits	Asthma Symptom Days	Restricted Activity Days	Acute Respiratory Symptoms	Child Bronchitis
$PM_{2.5}$									
2.5	112,579	292,172	23,234	19,586	107,721	30,415,382	333,670,100	503,581,300	2,261,584
20	64,564	167,556	13,325	11,232	61,778	17,443,222	191,237,730	288,804,270	1,299,367
30	32,824	85,352	6,774	5,710	31,408	8,868,053	97,345,840	46,826,740	658,256
40	10,288	26,728	2,123	1,790	9,844	2,779,362	30,488,790	46,017,370	206,703
PM_{10}									
5	139,769	472,547	32,886	27,827	154,312	43,510,880	468,311,800	1,363,340,400	4,288,765
25	107,257	362,632	25,237	21,354	118,418	33,389,855	359,324,300	1,046,215,600	3,282,563
40	60,211	203,814	14,167	11,987	66,476	18,744,032	201,833,250	587,313,100	1,845,243
60	19,097	65,001	4,493	3,802	21,084	5,944,991	64,277,040	186,276,370	578,470
80	2,469	8,316	581	492	2,726	768,717	8,228,000	24,086,462	76,955
Ozone									
60	7,546	N/A	5,092	N/A	21,759	5,222,126	20,322,774	39,296,490	N/A
70	5,278	N/A	3,562	N/A	15,219	3,652,443	14,214,094	27,484,635	N/A
80	3,094	N/A	2,088	N/A	8,922	2,141,245	8,333,013	16,112,869	N/A

Table H-4. Present Value Benefits of Achieving Alternative Reductions in Ambient Concentrations of $PM_{2.5}$, PM_{10}, and Ozone for Alberta for the Period 2005-2035 (central estimates, 1996$thousands, discount rate 5%, and base year 1996)

Pollutant/ Scenario	Total	Mortality	Chronic Bronchitis	Respiratory Hospital Admissions	Cardiac Hospital Admissions	Emergency Department Visits	Asthma Symptom Days	Restricted Activity Days	Acute Respiratory Symptoms	Child Bronchitis	Household Material Soiling
$PM_{2.5}$											
2.5	$14,258,662	$11,406,614	$1,844,823	$3,789	$4,065	$1,517	$34,575	$582,709	$186,670	$18,896	$175,006
20	$4,557,628	$3,646,302	$589,424	$1,211	$1,299	$485	$11,052	$186,189	$59,672	$6,047	$55,943
30	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
40	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
PM_{10}											
5	$15,797,629	$11,805,387	$2,486,729	$4,471	$4,815	$1,812	$41,232	$681,677	$421,290	$29,871	$320,335
25	$11,300,607	$8,446,379	$1,777,446	$3,199	$3,445	$1,296	$29,500	$487,310	$301,419	$21,417	$229,190
40	$4,921,786	$3,680,499	$772,503	$1,394	$1,501	$564	$12,854	$211,869	$131,343	$9,384	$99,869
60	$367,662	$275,108	$57,553	$104	$112	$42	$960	$15,791	$9,817	$706	$7,465
80	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Ozone											
60	$913,133	$869,668	N/A	$944	N/A	$348	$6,752	$18,851	$16,568	N/A	N/A
70	$438,467	$417,596	N/A	$453	N/A	$167	$3,242	$9,051	$7,955	N/A	N/A
80	$0	$0	N/A	$0	N/A	$0	$0	$0	$0	N/A	N/A

Table H-5. Total Avoided Health Events for Alternative Reductions in Ambient Concentrations of $PM_{2.5}$, PM_{10}, and Ozone for Alberta for the Period 2005-2035 (central estimates)

Pollutant/ Scenario	Mortality	Chronic Bronchitis	Respiratory Hospital Admissions	Cardiac Hospital Admissions	Emergency Department Visits	Asthma Symptom Days	Restricted Activity Days	Acute Respiratory Symptoms	Child Bronchitis
$PM_{2.5}$									
2.5	8,391	20,917	1,732	1,460	8,029	2,266,913	24,074,450	37,532,790	183,845
20	2,682	6,683	554	467	2,566	724,654	7,692,386	11,997,962	58,834
30	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0
PM_{10}									
5	8,684	28,195	2,043	1,729	9,588	2,703,405	28,163,294	84,706,670	290,621
25	6,213	20,153	1,462	1,237	6,860	1,934,200	20,133,101	60,604,910	208,366
40	2,707	8,759	637	539	2,989	842,826	8,753,314	26,408,537	91,304
60	202	653	48	40	223	62,999	652,439	1,973,976	6,873
80	0	0	0	0	0	0	0	0	0
Ozone									
60	640	N/A	432	N/A	1,845	442,709	1,722,877	3,331,388	N/A
70	307	N/A	207	N/A	886	212,580	827,289	1,599,661	N/A
80	0	N/A	0	N/A	0	0	0	0	N/A

NOTE: Although the MSG agreed that there are significant information gaps to be filled regarding the estimation of benefits, there was no consensus within the group about the usefulness of presenting these tables.

Appendix I. Control Cost Details

Table I-1. PM Reductions Needed in Urban Centres to Achieve Optional PM CWS Levels

CWS Level		Alberta Ambient Level	
PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	Reductions Needed (%) - Urban	
80	40	(0) $PM_{2.5}$	(<10) PM_{10}
70	35	(0) $PM_{2.5}$	(10-30) PM_{10}
60	30	(0) $PM_{2.5}$	(10-30) PM_{10}
50	25	(0) $PM_{2.5}$	(30-50) PM_{10}
40	20	(0) $PM_{2.5}$	(50-70) PM_{10}

Table I-2. Ozone Reductions Needed in Urban Centres to Achieve Optional Ozone CWS Levels

CWS Level (ppb-8hr)	Alberta Ambient Level Reductions Needed (%) - Urban
70	(0-10)
65	(10-20)
60	(10-20)
55	(20-30)

Table I-3. Summary of Estimated Costs of Achieving Optional PM and Ozone CWSs (Annual Costs in $M/yr)

PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	Ozone (ppb)	Alberta	Canada
70	35	70	72	962
70	35	65	200	2,043
60	30	65	300	2,494
50	25	65	440	3,471
50	25	60	670	8,102
50	25	55	850	19,260
40	20	55	4300	>>22,130*

** > signs indicate situations where cost estimates could not be made for the emission reduction levels required to achieve that particular CWS option.*

Table I-4. Provincial Cost Summary for Optional PM and Ozone CWSs – Alberta

Ozone (ppb)	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)		PM_{10}	$PM_{2.5}$	SO_2	NOx	VOC	Total
70	70	35	% Red'n	0	0	0	10	10	
			Cost ($M/yr.)	0	0	0	22	50	72
65	70	35	% Red'n	0	0	0	20	20	
			Cost ($M/yr.)	0	0	0	45	154	199
65	60	30	% Red'n	20	0	0	20	20	
			Cost ($M/yr.)	100	0	0	44	154	299
65	50	25	% Red'n	30	10	10	20	20	
			Cost ($M/yr.)	211	15	18	45	154	444
60	50	25	% Red'n	30	10	10	30	30	
			Cost ($M/yr.)	211	15	18	76	350	670
50	50	25	% Red'n	30	10	10	40	40	
			Cost ($M/yr.)	211	15	18	118	485	845
55	40	20	% Red'n	45	20	20	40	40	
			Cost ($M/yr.)	545	43	45	117	485	1,236

Table I-5. Estimated Costs of Achieving Optional PM and Ozone CWS Levels as % of 1995 GDP

Levels	Pollutants			Annual Abatement Costs as a percentage of GDP (1995)	
Levels	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	Ozone (ppb)	Alberta	Canada
A	70	35	70	0.08	0.12
B	70	35	65	0.23	0.25
C	60	30	65	0.34	0.31
D	50	25	65	0.50	0.43
E	50	25	60	0.76	1.00
F	50	25	55	0.97	2.39
G	40	20	55	1.41	2.74
GDP (Mill.$)				87,647	806,778

In order to provide some perspective as to what the costs of the various options mean relative to the Canadian and Alberta economies, the costs contained in Table I-3 are presented in Table I-5 as a percentage of provincial and national GDP.

Reviews of literature on pollution abatement and control expenditure indicate that the share of cost of pollution abatement in the GDP ranges from 1 to 2%, and that of air pollution control ranges from 0.2 to 0.4%. According to the recent OECD document, the share of total cost of pollution abatement as a percentage of GDP for Canada is about 1.2%. This cost includes not only air, but also waste and water. The CWS option thus would appear to represent a significant increase in environmental expenditures.

Appendix J. Examples of Management Options Identified in Other Jurisdictions

This Appendix features examples of measures being considered by two jurisdictions – the Government of Canada, and Phoenix, Arizona. These examples illustrate the range of possibilities and do not represent an exhaustive list of options, or options that have been endorsed as relevant for Alberta. Some of these measures may in fact propose legislation or agreements to introduce "control technology" components.

Government of Canada

In June 1999, the federal government released a discussion document in which it identified 22 possible new initiatives to reduce emissions of smog precursor substances. These were initiatives that the federal government could implement itself or could take a lead role in implementing with the concurrence and participation of the provinces.[52] The following initiatives were identified in the Phase 3 Federal Smog Management Plan.

Transportation and Petroleum Fuels

#1 **On-Road Vehicle Emissions**: Implement new on-road motor vehicle emission standards to match those being put in place in the USA.

#2 **Off-Road Engine Standards**: Negotiate Memoranda of Understanding (MOU) with manufacturers for new, diesel engines used in heavy-duty off-road applications and for new, gasoline recreational marine engines and new, gasoline utility engines, consistent with current US emission standards.

#3 **Inspection and Maintenance Programs for On-Road Heavy Duty Diesel Vehicles**: Develop a CCME code of practice for in-use inspection and maintenance of on-road, heavy duty diesel vehicles.

#4 **Fuel Dispensing**: Promulgate a federal regulation for fuel dispensing flow rates.

#5 **Sulphur in Gasoline**: Continue with adoption and implementation of federal regulations.

#6 **Diesel Fuel**: Consider ways to reduce sulphur content and/or modify other characteristics of diesel fuels, for on-road and off-road uses.

#7 **Rail:** Develop further MOUs limiting NOx from the rail industry.

#8 **Marine**: Via the International Maritime Organization (IMO), develop international controls on the sulphur content of marine bunker oils and international standards for NOx emissions.

#9 **Aviation**: Work with the International Civil Aviation Authority (ICAO) to reduce NOx and PM emissions from the aviation sector.

#10 **Heavy Fuel Oil**: Consider ways to reduce sulphur content and /or modify other characteristics of heavy fuel oil.

Stationary Sources

#11 **Electric Power Sector:** In consultation with stakeholders and the provinces, develop and implement plans for reductions of emissions of smog precursors from both new and existing fossil-fuelled power plants.

#12 **Residential Wood Combustion**: Establish public education, model municipal by-laws, further CSA (Canadian Standards Association) standards and possible federal regulation to promote clean burning residential wood heating appliances.

[52] Discussion Document on the Phase 3 Federal Smog Management Plan, July 1999. Government of Canada.

#13 **a) Pulp and Paper b) Wood Industries:** Assess current industry emissions, explore options to develop and implement emission reduction plans via a CCME Code of Practice or other appropriate tool (for both new and existing facilities).

#14 **Metals Sector**: Develop emission reduction plans for the iron and steel sector and the base metals smelting sector and implement via a MOU or other appropriate tool.

#15 **MOU with Canadian Chemical Producers Association**: Develop an Annex to address reductions in VOC emissions.

#16 **Commercial Building Incentive Program**: Provide incentives for energy efficiency in new commercial and institutional buildings.

#17 **Energy Innovators Plus**: Support organizations in reducing energy operating costs and greenhouse gas emissions.

#18 **Renewable Energy Deployment Incentive**: Provide Funding to corporations for renewable energy systems.

#19 **Federal Government Operations**: Reduce emissions from Federal Government sources.

Education

#20 **Public Education on Smog:** Educate the public on the impacts of smog and what individuals and organizations can do to help solve the problem.

#21 **Sustainable Agriculture**: Encourage farming practices that reduce windblown soil and ammonia releases.

International Advocacy

#22 **International Advocacy**: Participate in Canada / US Air Quality Agreement and the UN ECE LRTAP (United Nations Economic Commission for Europe Region Long-range Transboundary Air Pollution)

Phoenix, Arizona

Ninety-nine possible control measures were identified in 1998, during the development of an Implementation Plan to control PM_{10} emissions in Phoenix, Arizona.

Paved Road Dust – Reduce Dust (Silt) Loading

#1 Pave, vegetate, or chemically stabilize access points where unpaved traffic surfaces adjoin paved roads.

#2 Require haul trucks to be covered.

#3 Provide for traffic rerouting/rapid clean-up of temporary sources of dust (water erosion, track out, material spills).

#4 Improved material specification for de-icing materials.

#5 Require curbing and pave or stabilize road shoulders.

#6 Provide for stormwater drainage to prevent water erosion onto paved roads.

#7 Mitigation of freeway construction impacts.

Paved Road Dust/Tailpipe Emissions – Reduce Vehicle Miles Travelled (VMT)

#1 Implement short range transit improvements.

#2 Implement long range transit improvements.

#3 Require exclusive bus lanes on arterials and freeways.

#4 Expand MAG[53] rideshare program.
#5 Adopt trip reduction ordinance.
#6 Establish voluntary "no drive" days.
#7 Establish an area-wide public awareness program.
#8 Build/establish park and ride lots.
#9 Provide employees financial incentives (e.g., zero bus fares) in lieu of parking.
#10 Require employers to provide preferential parking for car and van pools.
#11 Require mandatory parking charges for employees.
#12 Build High Occupancy Vehicle (HOV) lanes on freeways.
#13 Build HOV lanes on arterials.
#14 Build HOV ramps which bypass metering signals.
#15 Promote increased bicycle use.
#16 Provide or require bicycle travel (e.g., lanes) and support facilities (e.g., lockers and racks).
#17 Promote pedestrian travel through provisions of pedestrian facilities (e.g., sidewalks).
#18 Provide pedestrian overpasses.
#19 Promote the use of/require employers to provide alternative work hours.
#20 Promote the use of/require employers to provide alternative work weeks.
#21 Promote the use of telecommuting.
#22 Promote the use of teleconferencing.
#23 Provide auto free zones and pedestrian malls.
#24 Provide vanpool purchase incentives such as tax breaks.
#25 Require merchants to provide alternative transportation incentives to customers.
#26 Implement congestion pricing.
#27 Require non-employee parking to be priced.
#28 Impose fee on vehicles related to emissions (smog fees).
#29 Encourage private sector transit by state deregulation.
#30 Evaluate and mitigate air quality impacts from new development (indirect source review).
#31 Require increased land use density along transit routes.
#32 Provide a fee-based tradable travel permit program.
#33 Set up system of road pricing.

On-Road Vehicle Exhaust – Tailpipe and Non-VMT Reduction Measures

#1 Expand current Inspection and Maintenance (I/M) to all model years.
#2 Expand the current I/M program state wide.
#3 Expand the current I/M program county wide.
#4 Require the use of No. 1 diesel fuel.
#5 Require clean fuels for fleet vehicles.
#6 California new car standards.
#7 Reduce cold start emissions.
#8 Scrap higher polluting vehicles.
#9 Reduce idling at drive up facilities.
#10 More strictly enforce traffic, parking, air pollution regulations.

[53] Maricopa Association of Governments – the Council of Governments serving as the regional agency for the Phoenix area.

#11 Freeway surveillance.
#12 Ramp metering and signage.
#13 Traffic signal synchronization.
#14 Reversible lanes on arterials.
#15 One way streets.
#16 Truck restrictions during peak periods.
#17 Intersection improvements.
#18 On-street parking restrictions.
#19 Bus pullouts in curbs.
#20 Alternative fuels for buses/electric shuttle buses.
#21 Emission controls on public diesel vehicles.

Dust from Unpaved Road/Parking

#1 Pave or otherwise stabilize permanent unpaved haul roads and parking or staging areas at commercial, municipal, or industrial facilities.
#2 Require sources to submit dust control plans.
#3 Develop traffic reduction plans on unpaved roads.
#4 Limit use of recreational vehicles on open land.
#5 Pave or stabilize unpaved roads.
#6 Pave or stabilize unpaved parking areas.
#7 Require controls on material storage piles.
#8 Require stabilization of wind erodible soils.
#9 Require windbreaks, watering, paving, vegetating for windblown dust.
#10 Restrict blowers for landscaping.

Agricultural Sources

#1 Rely on soil conservation requirements (e.g., conservation plans) of the Food Security Act.
#2 Require windbreaks for agricultural sources.

Residential Wood Combustion (RWC)

#1 Establish an episodic curtailment program for RWC.
#2 Establish a public education/information program for RWC.
#3 Encourage the improved performance of RWC devices.
#4 Provide inducements to reduce number of RWC devices.

Other Area Sources

#1 Develop a smoke management program for prescribed burns.

Point Sources

#1 Reasonable Achievable Control Technology for stationary sources.

Marine Vessel/Ports

#1 Divert port related truck traffic to rail.
#2 Control emissions from ship berthing facilities.
#3 Control fugitive emissions from marine vessels.

#4 Control emissions from marine diesel operations.
#5 Limit the sulphur content of marine fuel.

Locomotives

#1 Reduce rail crossings.
#2 Control switching locomotives.
#3 Electrify rail lines.

Airplanes/Airport Ground Equipment

#1 Centralized airport ground power systems.
#2 Reduce emissions from airport ground access vehicles.
#3 Establish tighter emissions standards for new jet engines.
#4 Control emissions from aircraft and ground service vehicles.
#5 Require replacement of high emitting aircraft.
#6 Require general aviation vapor recovery.

Other Non-Road Engines

#1 Establish emission standards for small utility equipment.
#2 Establish emission standards for new heavy-duty construction equipment.
#3 Establish emission standards for off road motorcycles.

Miscellaneous Measures

#1 Expand PM_{10} monitoring network.
#2 Move state fair to a different time of the year.
#3 Winter daylight savings time.

Appendix K. Potential Actions for Implementation[54]

This list of potential actions was developed at the National Multi-Stakeholder Consultation Workshop hosted by the PM and Ozone CWS Development Committee in May 1999. It is included here for illustrative purposes only and does not indicate endorsement by the MSG.

Issue and Sector-Specific Actions

Consumer Products

- Review standards of pressed fire-logs, including impact labeling to the public
- Mufflers for small gas engines (e.g., lawnmower, snowblowers, etc.)

Energy Efficiency

- Energy efficiency programs should be considered
- More efficient consumption of energy regarding timing, avoid peak periods: improving energy consumption practices

Cost-saving labeling on energy saving on all appliances (Canadian Energuide) Industrial Processes

- Timeline for industry to come up with action plans to reduce emissions three months prior to going to CCME; if not, propose six months for those industries who can meet it; industry will go back to Associations sectors and come up with plans to reduce emissions "early wins."
- Voluntary emission reduction commitments, avoid regulatory obstacles (e.g., permit requirements)
- Some tracking can be done within associations. Assemble trend data, and internal competition. Compile information on actions that are currently underway, so that we can build on these as case studies as actions that others can take (e.g., Voluntary Challenge and Registry [VCR], Accelerated Reduction / Elimination of Toxics [ARET]).
- Get industry to study plants, municipalities and provinces to monitor, pool results and resources
- Promotion of life cycle analysis (cross impacts)
- Develop best management practices for industry (e.g., capital stock turnover practices in every industry)
- Replace obsolete equipment/technology with cleaner technology
- Explore alternative industrial processes - emission reduction technologies
- Reduce/replace solvent use
- Improve waste incineration practices

Transportation and Petroleum Fuels

- Encourage mass transit ; need transit action plans for major urban centres; need a national strategic transit system in Canada; remove federal taxation for employees transit pass; find ways to improve the rider ratio for public transportation
- Cleaner fuels to provide and maintain real-world benefits of vehicle emission control technology; improve vehicle emission standards and fuel efficiency standards; Broaden Air Care and Drive Clean programs to more jurisdictions in Canada. Need leadership by example from governments i.e., be first off the mark - governments must demonstrate leadership with vehicle fleets, switch to alternative fuels

[54] CWS for PM and Ozone Multi-Stakeholder Consultation Workshop, Toronto, Ontario. May 26-28, 1999.

- Vehicle inspection programs - heavy duty diesel vehicles often not well maintained
- Reduce passenger vehicle use and total kilometres traveled through improved urban planning
- Elimination of manganese from gasoline
- Voluntary vehicle scrappage program
- Shift away from two-stroke engines. e.g., California is going to ban two-stroke outboard motors
- Encourage car-pooling or telecommuting
- Anti-tampering (e.g., catalytic converters)
- Elimination of subsidies to petroleum interests
- Reduce sulphur levels in gasoline - i.e., move sulphur in gasoline down to 30 ppb range by 2004?
- Divert some heavy trucking freights to rails
- Mandatory implementation of heavy duty diesel Inspection and Maintenance programs
- Sanding on roads in winter - sand could be recycled

Stationary Sources

- Develop EPA or some type of federal standards for wood stoves, this would result in a major reduction
- Improving residential building codes to R-2000/C-2000; Incentives for energy efficiency improvements in houses
- Regulated caps on utilities; fossil fuel, pulp and paper emission caps
- Establish policy for use of alternative fuels/renewable energy; assess opportunities to use renewable energy technologies
- Implement solar energy into building codes. Face houses to south
- Reduce coal use (combustion) in construction practices
- Look for actions in sectors that are major contributors (e.g., electric power plants, pulp and paper, petroleum refineries)

Education

- Small companies need education and technology assistance, they lack resources and knowledge for why and how to make reductions
- Educational program and regulation for crop residue burning, land clearing - encourage best practices; i.e., for small forest operators (can use the trees from land clearing in some areas for other purposes)

International Advocacy

- Government should consider funding groups that will work with counterparts in the U.S. on the reduction of transboundary pollution (e.g., New England States and Eastern Provinces); federal government adopt an aggressive action plan to lobby US transboundary emissions
- To ensure a successful lobby with US need to ensure with comparable emission reduction measures in Canada
- Look at what the US is doing and "piggyback" on their efforts

Support Activities

- Maintenance of current air quality index's reporting systems on extreme pollution levels; smog forecasting inclusion of PM and ozone
- Revise/improve ambient air quality index - make it more relevant, consider ability to harmonize it with other air issues and improve its dissemination

General Approaches to Strategy and Implementation

- Climate change initiatives must be linked or complementary to smog and other air initiatives; should be integrated into a holistic package; e.g., link to Phase 3 Federal Smog Management Plan
- Need to develop a process to bring all stakeholders with all sources and concerns to table; e.g., lawn mowers generate more emissions than some vehicles in some instances. Other industries not here should be at the table; must involve municipalities - important decisions made at that level
- Define provincial implementation plans - implementation plans need to consider broad base as well as community specific initiatives in PM and Ozone Strategy; e.g., Vancouver has a lot of small-scale initiatives. Furthermore, a proposal was put forward that each jurisdiction should develop a comprehensive multi-stakeholder process by June 2000 regarding their implementation strategy with initial actions by fall 1999
- Moratorium for plant permits in areas where there are exceedances; around bad air quality days agreement to manage these episodes, impose restrictions on industry, municipalities, public; e.g., do not mow lawns; cut back industrial processes, do not drive
- Make green energy available to consumers who are interested in buying it and may be interested in paying a premium
- Need to develop clear forest fire fighting policies and put more money into fighting such fires - also look at forest fire prevention; establish mechanism for informing the public about the effects of forest fires
- Examine what municipalities can do (e.g., reduce construction dust, targeted paving, landfills land reserves, implement community energy systems, consider air quality issues in their city planning, etc.)
- Need for new source performance standards
- Need for maximum emission standards
- Need collaborative processes for developing implementation plans e.g., renewable energy
- Develop and implement pollution prevention programs
- Require offsets for new developments in an attainment area; ensure an equivalent reduction within airshed
- Bottom up approach is needed whereby "airsheds" or zones would develop implementation plans that would address emissions specific to their own particular situation and be accountable for implementation
- Mandatory implementation of all measures in the Phase 1 NO_X/VOC Management Plan by 2005
- Legal authority for regional management needed
- Multi-pollutant sources should be addressed first
- Look at emissions trading within regional airsheds
- Set up a incident reporting/whistle blowing protection program
- Establish a government recognition program for "green" companies
- Develop and implement emission reduction strategies (e.g., at the provincial level)

Approaches to Funding and Incentives

- Tax incentives for zero emission energy production - encourage use of renewables; economic incentives/instruments - financial incentive for risky or new and cleaner technology (e.g., provide incentives to upgrade fleets)
- Federal/provincial funding for airshed/municipal actions
- Green budget
- Polluter pays principle
- Provide credits/incentives for early attainment and disincentives for non-attainment

Cross-Cutting Themes

Improve Monitoring

- Improve ambient monitoring - location of sites (more sites, more diverse locations: Canada-wide, rural sites and near industry towns e.g. where forest industry exists), continuous monitoring, develop measurement methods and protocols (i.e., what will be measured, when will it be measured and how will it be measured, when will it be reported)
- Need a strategy for better using existing ambient air quality information that is available from all government database sources and use this data for emission reduction strategies
- Are the control devices used by industry capturing $PM_{2.5}$? Need proper measuring devices to obtain good information.
- Need to monitor and understand sector-by-sector source
- National Pollutant Release Inventory (NPRI) is useful. What you don't measure, you can't control or improve. NPRI needed to create industry awareness of emissions in order to get programs created to control them.

More Research/Data Collection

- We need a strategy for gathering data and interpreting data
- Work to fill in data gaps and look at new technology
- Invest more dollars into health research on air quality and provide better coordination of research among various air issues (e.g., PM, Ozone, Climate Change, etc.)
- Conduct more research on transboundary impacts
- Need for research and eco-monitoring into vegetation, forestation and agriculture and their effects from air pollution
- Make an investment in research e.g., renewable energy
- Improved economic analysis; Cost Analyses; Inventory of (sociologically-based or non-technological) options and how to implement them and build them into the cost models
- Initiate research on improved monitoring and control equipment
- Emissions Estimates; Improve understanding of emissions e.g., PM speciation; $PM_{2.5}$ - we need more data on it (i.e., what components of $PM_{2.5}$ affect health the most)
- Power generation – need to work on primary and secondary PM, need methodology
- Private sector analysis of what is the problem at a facility-level
- Develop predictive model for ambient air quality (secondary aerosols)
- Develop source apportionment methodologies – by areas/region (may need models specific to regions), via modeling; examine the source ambient receptor relationship, identify all sources
- Improve inventories of emissions (stack and fugitive); there is a need for industry groups to go back to their associations, get all the data available and find out what we know and what we don't know; develop an inventory of sectors' emissions of PM, PM and Ozone precursors; suppliers of abatement collection equipment need to ensure quality of PDTS to get more precise inventory; Inventory, apportionment and the relative costs of measures are important in emission reduction scenarios
- Review American research program to Canadianize

Public and Stakeholder Education and Involvement

- Mass education - general public, industry, government; provide training and information/data (e.g., in booklets or other communications vehicles) on the issues associated with PM and Ozone (e.g., local conditions, authority/responsibility, local sources, indoor air quality and what people can do to help reduce emissions of PM and Ozone; key is to provide all information in plain language)

- Should be a process of early childhood education on consumption, and provide consumer-friendly indicators, (e.g. report card which public can understand their own use/behaviour/lifestyle)
- Certificates of approval. Public comment periods on these. Can promote mediating role with industry.
- We also need motivation by an informed and educated public and good relations between stakeholders
- At the natural gas/co-generation unit, a liaison committee between industry and environmental groups successfully engaged in shared problem solving and advisory panels
- Multi-stakeholder group needed who will be in a position to evaluate science for CWS. Make CAG more like CASA at a national level. Build on national opportunities to use mechanisms for increasing awareness and understanding. Use NGO infrastructure
- Jurisdictional, multi-stakeholder consultation needed to determine their issues, their mechanisms. Multi-stakeholder consultation will help to integrate for national information exchange
- Form a national education steering committee from stakeholder representatives possibly integrate with the Climate Change Public Education Outreach Program